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THE RELATIONS OF EMBRYOLOGY TO MEDICAL PROGRESS[1]

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EMBRYOLOGY is the most complex subject in the domain of science. Living beings are the most complex objects which nature offers us for study, and of this great class the higher animals exceed all others in complexity. The anatomist who studies the structure of the adult has a finished apparatus to investigate; a machine which has been perfected, in which, to be sure, nature may still make repairs, but in the pattern of which she makes no radical changes. The physiologist deals with this machine at work. The embryologist, on the contrary, has for his theme the history of this machine and of its gradual production from a single cell and the progeny thereof. During the period of development the machine at every stage is a different machine from that which it was in the stage before and which it will become in the stage after, and yet in every stage it is actively at work performing its proper physiological functions. We have to deal not with a condition, but with a series of conditions, each of which is at once the consequence of that which went before and the cause of that which is to follow. The final problem of embryology is to determine the origin and cause of the structure of the living body, and incidentally it has to deal with the associated problems of teratology, growth, heredity and sex.

We acknowledge the immensity of the questions for which embryological science must seek answers, but it is far from my intention

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to imply that embryologists therefore are an order of scientists superior to all others. Embryology is so vast and varied that it offers problems adapted, I might almost say, to every size of mind, and persons of moderate capacity, as well as those of the highest gifts of genius, can find adequate opportunity to gratify successfully in the field of embryology any demon of research which may possess them.

Let us first consider some of the conditions upon which the progress of embryological science has depended. Of course the first and all-essential thing is the amount and quality of human ability which has gone into it. This is true of every science, as goes without saying. It may, however, be interesting to pause a moment, since contemporary events are directing so much of the interest of the world towards Russia, in order to point out that modern scientific embryology had its birth in that country, for the first step was the publication of the articles by C. F. Wolff on the 'Theory of Generation and the Development of the Intestine in the Chick'; and the second and more important step was the publication of the great work of Carl Ernst von Baer, which may be said without exaggeration to have created by itself a new science. Von Baer's treatise on the 'Entwickelungsgeschichte der Thiere' is one of the greatest works in the whole history of biological science, and established the author's reputation as a genius of research. By the aid of improved methods a tyro in embryology may now verify von Baer's discoveries, but there has been no one since von Baer, who could have approached with his scientific resources the magnitude of his achievement. Let us then honor his memory. Although Wolff and von Baer, both, were Russian subjects, they were of German descent, and we find indeed that throughout the greater part of the last century the advance of embryology was due chiefly to German investigations.

How recent this knowledge is we are apt to forget. From 1800 to 1840 the seminal animalcules were universally regarded as parasites. The fact that they are normal products of the testis and the true male sexual elements was first discovered in 1841 by the Swiss anatomist von Kölliker, who was a leader in microscopical research for sixty-five years, and whose death occurred last year. Of Kölliker it may be asserted safely that he knew more by direct personal observation of the microscopical structure of animals than any one else who has ever lived. He was much honored in Europe. The last time I met him was at the International Zoological Congress at Berne, in 1894. It was most impressive to see all the members of the congress spontaneously rise to their feet when the handsome old man unexpectedly entered the meeting. The fact that the spermatozoon enters the ovum and produces the so-called male pronucleus, the union of which with the female pronucleus completes the act of fertilization, was finally demonstrated only in 1875 by Oscar Hertwig. These two

additions to our knowledge are so fundamental that we have become rapidly familiar with them, and easily forget how recently they have been added to our science. Many other illustrations of the newness of embryological knowledge might be given.

The methods used by von Baer and by all his successors in embryology down to 1860, or even later, were exceedingly simple. They worked almost entirely with fresh material, hand lenses, and sometimes with acetic acid to render the objects a little more transparent. The embryologists of that period were few in number, but they made many fundamental discoveries. I fancy that if the researchlings of our present luxuriously installed laboratories were put back into that time of lean resources, their publications would cease. As you know, the fundamental procedures in modern microscopical technique are the making of sections and the staining of them. The introduction of section cutting came about so gradually that its history seems to be lost to us. Many persons in the middle of the last century appear to have made sections by hand of various tissues. This was especially a practise among botanists. At first only fresh material was used, but it was learned that preserved material, especially that which had been properly hardened in alcohol, could be cut to greater advantage, and gradually the process of 'hardening' before cutting became more and more common. So long as the cutting was done only by hand with that favorite unsuitable instrument of old days, the razor, no very fine sections were possible, save occasionally by some person of exceptional dexterity. The first microtome, so far as known to me, was that devised by Professor His and employed by him, about 1866,[2] for making serial sections of chicken embryos. Since then many inventors have contributed to the perfection of the instrument, and we now have the rather complex but very accurate and convenient automatic microtomes which are in such general use.

With the aid of microtomes, we can make perfect series of sections, and by mounting the entire series from a given object, it becomes possible to examine every part of it under the microscope. In the case of embryos serial sections are invaluable. We have been forming in my laboratory at the Harvard Medical School a collection of such series of sections of vertebrate embryos. The total number of series at the present writing is 1,106, of which forty-nine are from human embryos. The total number of sections is probably over 100,000. This collection has already served as the basis of forty-two embryological investigations and we trust that it will serve in the future for very many more. So far as I know the collection is unique in plan and extent. As soon as we are established in our superb new laboratory, into which we are about to move, we shall be glad to have

[2] Described in the *Archiv für mikroskopische Anatomie*, 1870.

you inspect our embryological museum. We value especially a fine human embryo which is in the youngest stage yet recorded by actual observation in America.

The history of staining is more definite. I have had the pleasure of hearing from Professor Leo Gerlach, Sr., himself the story of the introduction of coloring matters in microscopical technique. He was interested about 1857 in studying blood vessels, and wishing to trace them out by injection, applied to a local apothecary at Erlangen for a suggestion of some red coloring matter, and the apothecary proposed that he should use an ammoniacal solution of carmine, the pigment extracted from the cochineal insect. Professor Gerlach employed it, and in examining some of his preparations later found that the color had soaked through the blood vessels into the surrounding tissues, and had stained them so that they were much more distinct, and he also noticed that the stain had especially affected the nuclei. He at once recognized the importance of this coloration as a means of rendering more clear the character of cells and tissues, and to him we owe the introduction of carmine into histological technique, and it remains to-day the most important and valuable coloring agent for our purposes which we possess. The introduction of carmine marks an epoch in microscopical science. It was most fortunate that the accidental observation of the action of carmine was made by a man so thoroughly able to appreciate its great value. Since then many other staining reagents have been introduced by many different persons. I need not pause now to enumerate them, or hold up your attention in order to give a list of names and dates such as could be easily compiled. I will only recall to your minds that the introduction of chloride of gold, of osmic acid, of the aniline dyes, and of the Golgi method have each of them represented the beginning of a fresh advance, which without these added technical resources would undoubtedly have remained impossible for us.

Another class of methods are those by which we reconstruct from serial sections the anatomy of an embryo or an embryonic organ. To the late Professor His, of Leipzig, we owe practically the first recognition of the value and possibility of such reconstruction. He employed chiefly the method of drawing, by which many figures have been made. The process is laborious, for each section must be drawn and then the position of the parts measured and plotted off—but the labor is worth while as it results in accurate representations of the anatomy of parts which can not be dissected. I am in hopes that in our new Harvard laboratories that this method of reconstruction from sections will be applied to the adult, for I am sure that we can obtain by it representations of adult relations far superior to anything we now possess.

Doubtless to many of you the method of reconstruction from sections in wax models is also well known and its value appreciated as a

means of giving us perfectly clear plastic conceptions of the arrangement of parts. The very ingenious wax-plate method was invented by the late Gustav Born, who conceived the happy idea of making wax models of single sections or parts of sections equally magnified in all three dimensions. It is only necessary to pile such wax plates in order, one on top of another, to get a correct model of the whole object. The method is very widely used and in my laboratory, for example, has been employed recently by Dr. John L. Bremer to model the anatomy of a human embryo and by Dr. John Warren to model the developing brain. Such models are truly revelations to one who has studied sections only.

This is not a suitable occasion to review the history of the technical progress of embryological science. I wish only to so far indicate it as may suffice to direct your attention to the dominant importance of method in scientific problems. It seems to me that the greater part of the advance which is made from time to time in modern science is the direct result of either an improvement of old methods or the invention of novel methods. I can see in my own science clearly that this has been the case, and from what I learn about other sciences, infer that it is equally true of them. Viewed from the psychological standpoint, the vast majority of methods have a common purpose, namely, to present the results to the eye, so that we can see what the facts are with which we wish to become acquainted. When we make sections, it is in order to see the cells in their natural relative positions, and with all their various characteristics. When we stain sections, it is in order to make things visible which were before indistinct or perhaps invisible. When we make reconstruction or models it is to furnish again an image to the eye which we can not get from the actual object itself. The eye, indeed, is the chief agent in collecting information for us from the objects by which we are surrounded. It is because they help out the eye that the microscope and telescope have counted for so much. The eye is almost the monarch of research, and reigns even more supremely over our relations with our surroundings than does the ear over our intercourse with our fellow men.

The results of embryology for a long time remained rather meager, and when as a young man I went to pursue some of my scientific studies in Germany, the principal text-book of the science was a modest octavo volume by Professor Kölliker. Since that time (1873) the activity in this domain has increased by leaps, and is now enormous, and the latest handbook of the science, that which is in course of publication at this time under the editorship of Professor Hertwig of Berlin, will comprise eight volumes, each of which promises to exceed a thousand pages when complete; yet the work is only a digest of the researches upon the development of vertebrates and does not

deal with the invertebrates at all. This bald statement may give you some impression of the present vast extent of the science.

What I wish to attempt on this occasion is to select out of this huge accumulation of discovery some illustrations of the way in which embryology has made contributions of practical value to medical science and medical practitioners. I have on another occasion spoken of the relations of science and the scientific spirit to medical education and practise, and on yet another occasion have discussed embryology as a basis of pathology, so that it seems unnecessary to deal again and before you with these more general aspects of the situation, but I shall ask your attention rather to certain more detailed and specific examples.

Every science has its larger aims and purposes. Those of embryology may be classed not unnaturally under five heads. First, I shall group together those researches that refer to the general topic of generation, the production of the new being, the conditions under which it first develops, including, of course, for man especially, the relations of the fruit to the womb. Under this head are comprised phenomena of impregnation, problems of heredity, the origin of sex, the conditions of gestation and pregnancy, and the physiological causes of birth.

Secondly, under the head of cytomorphosis we can put all the work which has been accomplished in tracing out the development of cells. The conception of cytomorphosis is one which has only recently become clear to us, but it is one of the most fundamental notions of biological science, and one which every student of morphology, pathology or physiology must clearly grasp and keep constantly in mind. Cytomorphosis has been defined as the comprehensive designation for all the structural modifications which cells or successive generations of cells may undergo from the earliest undifferentiated stage to their final destruction. It starts with the history of the undifferentiated cell, considers all phases of differentiation, and in those cases where the process goes to its end, it follows out the final steps of the degeneration and destruction of the cell. The law of cytomorphosis is indeed the chief foundation of all anatomical and pathological science. The possibilities of modification within a cell are determined by the stage of cytomorphosis which is reached, and as it goes forward from stage to stage the possibilities of further change become more and more limited in accordance with the recently established law of genetic restriction. I have expounded my views on the importance of the laws of cytomorphosis for pathology in the Middleton-Goldsmith lecture for 1901 and need not now dwell longer upon the subject.

Third, I should class the studies which refer to the germ layers, those laminæ of cells which, as it were, occupy an intermediate place between the single cell and the organ. They correspond to the first orderly arrangement of cells which we have in the organism, and from

this tripartite arrangement the organs are fashioned. Of course, the fundamental morphological fact in regard even to the higher animals is the cell, but next to that we may place the existence of the germ layers, the complicated interrelations of which dominate the entire history of every individual alike in health and in disease. The comprehension of the morphological importance of the germ layers and their relation to the production of tissues and organs and abnormal growths of all kinds is absolutely indispensable to every medical man who wishes to have an intelligent mastery of his subject.

Fourth, we may place the strictly anatomical aspects of embryology, which give the morphological interpretations of organs and the explanation, as you know, of many anomalies of adult structure. The anatomy of the adult offers to us many riddles, for numerous are the arrangements and characteristics of the body which we can not understand or explain from the study of the adult alone. The language of adult structure we often can not read unless we have first studied the Rosetta Stone of embryology which affords us the key of translation. As a teacher in a medical school, I have again and again been profoundly impressed with the value of embryology to the student of anatomy. Things which are obscure are illuminated by a knowledge of the developmental changes. In an embryo we encounter simplified conditions; secondary modifications coming in later in the course of development not only add to the complication of parts, but often also produce so great changes as to mask the fundamental and original relations. What student of adult anatomy alone could possibly discover that the thymus gland is a modification of the lining epithelium of a gill pouch which exists as a pouch in the embryo and is homologous with the gill pouch of a fish? Or what pure anatomist could ever have discovered that the spermiduct is the modified duct of a kidney present in the embryo, but which in the adult has as such totally vanished? If we pass from mere human anatomy to the larger and more scientific subject of comparative anatomy, we feel again the value of embryology, which establishes the real homologies of structure, proving exact homologies from the study of the early stages of parts, which in different types become so unlike that their fundamental identity of origin is completely hidden. For example, without embryology we never should have known that the little bone of the ear which we call the malleus is homologous with the upper part of the lower jaw of a cartilaginous fish. Indeed, the stories which embryology has to tell are the most romantic known to us, and the wildest imaginative creations of Scott or Dumas are less startling than the innumerable and almost incredible shiftings of rôle and changes of character which embryology has to entertain us with in her histories. I have been tempted to exclaim sometimes while pursuing my science that in embryology only the unexpected happens.

Fifth and last, I should like to gather under the head of morpho-physics a number of researches, nearly all of which are very recent, and which tackle the doctrine of the chemical and physical causes of development. These researches have been largely experimental in character, and though we are only at the beginning of this sort of work, yet the results already obtained are of the highest value and make us hope for far greater results to come.

There should be added logically a sixth heading for the physiology of the embryo, but so little has been done and so little is doing in this part of biology that only in the future can this logically correct sixth division correspond to a field of active research. Here poverty of achievement makes further present consideration by us superfluous.

It is unnecessary to argue in order to prove to you that the study of generation is of importance to the medical man. The results which embryologists have already offered in solving some of the problems of generation form part of the stock in trade of every practitioner, for every one must know something of the uterus and placenta, must know that there is no communication between the fœtal and maternal circulation—no passage of the blood from the mother to that of the child; that there is no machinery for the making of so-called maternal impressions; that conception depends primarily upon the fusion of two living elements, the ovum and spermatazoon, which arise as living and integral parts of the parental bodies, and must know thus that there is a continuity of life, an earthly immortality, and that from generation to generation life is uninterrupted. All these notions and many others derived from embryology are now-a-days part and parcel of every physician's information, and it is hard to realize that a short time ago many of these facts were unknown to us. I believe that in the course of the next few years many new discoveries concerning generation will be made which will in their turn become familiar to all. I expect especially in regard to the subject of heredity a great increase in our knowledge, because the subject has attracted many investigators and some notable results have already been achieved. I may instance the history of the germ cells in which I have been especially interested. Professor Moritz Nussbaum on the basis of certain observations which he had made, put forward in 1880 the theory of germinal continuity. He pointed out that there is noteworthy evidence in the development of various animals tending to show that the germinal cells from which the sexual products arise are separated off very early from the other cells of the embryo and undergo very little alteration until the time comes for them to be transformed into sexual elements, male or female, as the case may be. Dr. F. A. Woods, working in my laboratory upon the embryos of dog-fish brought the first conclusive demonstration that Nussbaum's theory is true for a vertebrate. He found that the germ cells are set apart, have a distinct

history of their own throughout the embryonic period and do not contribute in any way to the formation of any of the organs of the body. Since then Mr. B. M. Allen has discovered that the history of the germ-cells in the turtle is strikingly similar, and Dr. Woods is now engaged in tracing out the history in birds. Every one present will, of course, immediately recognize the great importance of a discovery which tends to show that there is a permanent distinction between the reproductive cells and the somatic cells which belong to the body and do not serve for reproduction.

Concerning cytomorphosis I need not add anything to what has been said concerning its general value in pathological study, but I should like to refer briefly to the good results which we may anticipate from direct application of the notions supplied by embryologists to the investigations which are yet to be made upon what we may call the morphological diseases, in distinction to those which are of parasitic origin. Morphological diseases arise through intrinsic causes, abnormal conditions due to the body itself and its reactions. Parasitic diseases have extrinsic causes. The dramatic—I might almost say melodramatic—growth of bacteriology and the kindred sciences has caused us to give most of our attention to diseases of the infectious type caused by some vegetable or animal parasite. This tendency is to be so far regretted that it has rendered investigation one-sided and lured it away from the class of diseases which may be attributed to pathological cytomorphosis. In regard to these the fundamental problem is identical for the pathologist and embryologist. It is the question of what and how the change in the structure of the single cell may be. Here is a central problem about which a vast number of lesser problems revolve like satellites. In the solution of this and of allied problems our greatest hopes for the future progress of medicine seem to lie. If we can find out what are the conditions which cause a cell to change its structure and advance in its cytomorphosis, we may hope that that discovery will include the explanation of why certain cells develop abnormally and become, as we commonly say, pathological, and we are to have precise knowledge of the cytomorphic causes we may dare, even now, to hope that we shall learn to regulate them, and that some, at least, of the diseases which are now beyond our reach will come under our control. It was not long ago that the idea of conquering diseases like malaria, yellow-fever, diphtheria and tuberculosis seemed a mere dream, a beautiful dream, yet control of them is now a reality, and is becoming almost daily more assured, complete and beneficent. So too in regard to the strictly morphological diseases, knowledge may bring mastery; and even sclerosis, that disease from which we are all assumed to be suffering in varying degrees, may, ere long, find itself subject to man.

Of the services which embryology has rendered to medical science

within the last twenty-five years, the best known and probably the most important, certainly the most spectacular and unforeseen, is the revelation of the structure of the nervous system and of the relation of the nerve cells to one another. This wonderful achievement has been due chiefly to the introduction of a single new method, named after its inventor Golgi, one of those brilliant modern men who prove that genius is still the gift of the Italian race. He was born at Corteno on the ninth of July, 1843. The method was first described in 1875 in an article on the fine structure of the olfactory bulbs. The method was so radically different from anything known at that time that it was treated with scornful incredulity, and no attention was paid to the new invention which was destined to revolutionize our knowledge until it was introduced in Germany by Professor Kölliker in 1887. This marvelous method has been found to work best with embryos and has enabled us to trace out the form, including their ramifications, of the nerve cells and neuroglia cells of the brain and spinal cord throughout their whole period of development. As you know, all our contemporary teaching in regard to the structure and functions of the central nervous system, our conceptions of the nervous mechanism within the central nervous system and in the ganglia, are based upon the results obtained through the application of Golgi's method by embryologists. It is pleasant to note that in 1903 the completion of twenty-five years of teaching, and, by a happy coincidence, the anniversary of his silver wedding, were celebrated by Professor Golgi's pupils by the publication of his complete works, 'Opera Omnia,' in three magnificent quarto volumes. Copies of this publication ought to be in every pathological and histological laboratory in the world. Indeed, every text-book of anatomy, embryology or pathology published now-a-days is a memorial of Professor Golgi, for they are all abundantly supplied with figures of Golgi preparations. We may see in this history an illustration both of the value of the embryological data and also of the almost creative power of a new method.

Degeneration has long been regarded as essentially a pathological process. This is the view which we have inherited. Nevertheless it is incorrect, as has been demonstrated by the more exact study of normal cytomorphosis during recent years. We now know that degeneration is to be looked upon as a normal end to a complete cytomorphic cycle. Instances of normal degeneration have long been familiar to us. Our mistake has been in overlooking their interpretation, their significance as part of the normal life. Thus the horny layer of the skin is made up of degenerated cells. Cartilage when it is replaced by bone undergoes a normal degeneration. In short, we must regard pathological degeneration very much as we regard those plants which we call weeds, things which are growing

from our human point of view at the wrong time and in the wrong place, but which are not of themselves wrong or diseased, though they become so in man's nomenclature by their mode of occurrence. This broader conception of degeneration affords a new foundation for further investigation, and by the hearty cooperation of the embryologist and the pathologist we may expect new enlightenment.

The fourth head under which we classed the work of embryologist corresponded to the field of anatomical research. We all know that the embryological explanation of the anatomical disposition in the adult is a real and clarifying explanation. Certainly no teacher of anatomy to-day, competent to his work, will undertake to teach the structure of the brain, of the urogenital system or of the heart, except on an embryological basis. But there are a great many other anatomical conceptions which may best be made clear if we start with an examination of the conditions in the embryo. My experience as a teacher has afforded me many examples of this. Let me mention a few. The arrangement of the great cephalic nerves is a subject of peculiar difficulty to the student, but by the examination of a few properly chosen sections through the head of mammalian embryos all the essential topographical relations can be made easily understandable, and these essential relations are never obliterated by any further development. The disposition of the peritoneum is one of the greatest bugbears to the first-year medical student. But let him study the peritoneum in its relation to the viscera in the young embryo and he easily overcomes his difficulties and gets a clear and correct conception of the topographical relations of the peritoneal membrane and is able thereafter to comprehend the secondary modifications by which the adult topography is so much complicated. So too in regard to the thorax, a few sections from embryos give definite and exact conceptions of the fundamental relations of the heart and lungs, the mediastinum, and of the pleural and pericardial membranes. A good student may obtain from such a section a visual image which he will carry with him throughout life and which will always serve to make clear in his mind all these anatomical relations. One more similar instance may suffice. Students are always perplexed by the nature and mutual connections of the three membranes of the spinal cord and brain. Here also experience convinces us that sections of embryos reveal the facts so perfectly that they are readily comprehended and not easily forgotten. But I think I need not argue further to convince you that embryology as an aid to anatomical study is of incalculable value, and ought, if we are to do our anatomical teaching conscientiously, to be included in every medical curriculum.

Not infrequently the study of embryos establishes entirely new anatomical conceptions. An instance of this is offered by the study of blood vessels. We have learned in recent years that in addition to

the long recognized arteries, veins and capillaries, there is another class of blood vessels of great importance. These vessels are called sinusoids and to a certain extent resemble capillaries, but their development and their relation to the parts of the organs in which they occur are entirely different from those of true capillaries. A sinusoid is developed by the subdivision of a single large vessel. It consists of endothelium, but that endothelium rests directly, or almost directly, upon the cells of the organ in which this type of vessel occurs. Capillaries, on the other hand, are developed as small buds from preexisting vessels and are always found in connective tissue. The most important organ in which sinusoids occur is the liver, and the peculiar circulatory arrangements in that organ, which have so long seemed singular and puzzling, have become comprehensible, and have acquired greater significance since the conception 'sinusoid' was established. This newly formed conception has unlocked the mystery of the portal circulation, and has explained the supply of venous blood to the liver. A morphological explanation of the portal vein had previously remained impossible.

To the fact that embryology explains many anomalies of the adult structure, we have already referred. Let us leave out of consideration the true monstrosities and confine our attention for the present to the anomalies, which are due to arrest of development. These are comparatively frequent, and many of them are so definite we may fairly call them typical. Such, for instance, is the preservation in the adult of the foramen ovale between the auricles of the heart, or of the open ductus arteriosus by which blood of the pulmonary and body circulation may mingle. In case of the veins also an arrangement of vessels is often found in the adult which is due to the persistence of a truly embryonic condition. The urogenital system seems to be peculiarly subject to arrests of development. When it starts the rudiments for both sexes are complete and the two sexes become differentiated largely by the obliteration in the individual of one sex of those structures which are characteristic of the other, but not infrequently it happens that this law of suppression is disturbed, and we then get very interesting and significant anomalies with which the physician often has practically to deal. Such cases do not produce a true hermaphroditism. That is a condition which apparently may occur in the human species, but is of the utmost rarity. Among other of the most frequent and familiar illustrations of arrested development I will mention cleft palate and hair lip. It is quite unnecessary to prolong this list, for it is evident that the anomalies we are considering are of a definite prescribed nature. They are all of practical importance to the physician, and unless he knows something of embryology he can not know what these probable anomalies are. If he does know something of

embryology he can understand much of what may be expected in this class of variations of structure.

We will turn now to the fifth and last of our headings, that of morpho-physics. It is only of recent years that methods of experimentation, as distinguished from methods of observation only, have been applied to embryological problems. Naturally under the circumstances many crude experiments have been undertaken, many of doubtful validity; but there have also been many others, soundly planned, rightly executed and fruitful in results. Already the new conclusions constitute an increment both large and precious to our stock of embryological knowledge. One important class of these experiments has been based upon the discovery of the possibility of grafting parts of amphibian embryos on to one another; or to get two large pieces of two distinct embryos, or even two halves of two embryos, to grow together. The grafting experiments which have already been made are very numerous. Let me present one or two examples of the sort of results that these experiments yield. If the halves of two species of frog in a very early stage are grafted together, they will unite perfectly, but it is found that the epidermis of the species which forms the anterior half of the graft will spread to a certain extent over the posterior half, thus showing that the skin can actually crawl over the underlying tissues. It is probable, indeed, that the migration of epithelial cells along the surfaces upon which they rest is a very general phenomenon, and plays a very important part in the animal economy. In another series of experiments the embryonic optic vesicle has been removed and grafted on to a new part of the larva. Where the optic vesicle comes in contact with the epidermis it causes the epidermis to form a typical lens for the eye. Thus it is proved that the formation of the lens is not a specific function of that part of the epidermis from which it is normally produced, but is a potential function of the entire embryonic epidermis which may be called forth into activity by contact with the growing optic vesicle. I believe that we have in this an illustration of one of the fundamental principles of the establishment of structure and that much depends upon the interaction and mutual stimulation of parts.

Another class of experiments has been conducted by those who have been somewhat jocosely named the 'egg shakers.' An egg during an early stage of segmentation is divided artificially into its natural segments, or into groups of such segments, as the case may be. In many cases this division can be accomplished by shaking the eggs somewhat violently so as to break the segmentation spheres apart; hence the name above quoted. Now it has been demonstrated that in some cases fragments of a single egg will develop into an embryo perfect apparently in structure, though only of say half the normal size,

whereas in other cases half an egg will develop only into half an embryo. Investigators are still busy studying out these results, the final interpretation of which has as yet by no means been reached. The experiments have opened to us a new realm of inquiry full of astonishing surprises.

Experiments on artificial parthenogenesis have been much written about in the daily press, and many absurd things concerning this topic have been printed in the newspapers. Ordinarily the ovum requires to be fertilized in order to develop, but it has long been known that certain ova, of bees, of plant lice, of some crustacea and of other animals will develop without being fertilized. To this process the term parthenogenesis has been applied. Artificial parthenogenesis designates the development of unfertilized ova which normally would not develop at all and which are stimulated to development by placing them under artificial chemical conditions. Doubtless many of you have seen in the newspapers these experiments referred to as if they gave the actual creation of life. Of course that is nonsense. The life is there in the ovum. What artificial parthenogenesis accomplishes is to supply a stimulus, chemical in nature and capable of replacing the fertilization by the spermatozoon, which would otherwise be necessary. The possibility of artificial parthenogenesis was first partially demonstrated by Richard Hertwig, but has been perhaps more studied by Professor Loeb, now at the University of California, than by any one else. Hertwig produced artificially only a development of very limited degree, but Loeb by treating the eggs of a sea-urchin for about two hours with a weak solution of magnesium chloride succeeded in 1899 in producing larval sea-urchins (so-called *plutei*) from unfertilized ova. He concludes from this that fertilization is a chemical process, and that it is distinct and separate from hereditary transmission. No words of mine are needed to emphasize the importance of such investigations, for they are basic.

A line of work combining experimental and observational methods in which I have been especially interested deals with the problem of growth. It can be shown statistically that the growth of the embryo in early stages goes on at an enormous rate, and also that during the period of fœtal development that rate is constantly declining, so that something over 98 per cent. of the growth power is lost by the time of birth. After birth decline in the growth power continues, but gradually the decline becomes slower and slower, so that though growth is slight in rate, the growth power is long continued. A study of the condition of cells while this decline of the growth power is going on reveals to us that while the growth power is rapid the nucleus of the cell is active and well developed, and that the protoplasm of the cell is but slightly developed. As the proportion of protoplasm in the cells increases the power of growth diminishes, and as differentiation

of protoplasm goes on the power of growth diminishes. I consider it probable that the growth and differentiation of protoplasm is the direct cause of the diminution of the growth power. The observations on growth bring out clearly to our minds the conception that the decline is by far the most rapid in the very early periods of embryonic development or, better expressed, that the rate of decline is at its maximum during the earliest periods. The older the individual becomes the less is the power of growth, but also the less rapid is the decline in that power. Thus we reach the paradoxical conception that the period of most rapid development is also the period of most rapid decline. This view, it seems to me, applies to all development, at least in the higher animals. As I have spoken on this subject more fully elsewhere, I will not pursue it longer now, but it seemed to me desirable to refer to it as an illustration of the far-reaching character and wide scope of embryological investigation, which inevitably allies itself with every other biological science.

It would be no difficult task to extend my discourse by multiplying illustrations of the beneficial influence of embryology upon other departments of medical science. It is one of the institutes of medicine—a part of the foundation of knowledge upon which medical practise is erected.

Embryology supplies facts which are directly valuable to the practitioner. It supplies explanations and interpretations of many anatomical structures and relations which would otherwise remain incomprehensible. It supplies the clues to many common and rare anomalies, and it supplies to pathology a series of fundamental conceptions, without which our actual present pathological knowledge could not have been upbuilt. These claims of embryology to recognition are very great, but nevertheless they do not include her greatest claim to a preeminent place among the medical sciences. That greatest claim is established in my opinion by the contributions of embryology to the solution of the problem of organic structure.

Structure is the only distinctive mark of living bodies, by which we know them to differ from inanimate objects. In the final discrimination between living and dead all other distinctions fail us or at best are utterly uncertain. In the higher forms we see differences of function always correlated with visible differences of structure. From such evidence, together with much other, we have established the hypothesis or theory—for at best it is only a theory—that all living functions are dependent upon organic structure. It is quaint, we may remark in passing, to read in recent essays by a learned German botanist the announcement of this theory, which the vast majority of biologists have long adopted, as a *new* foundation for biological philosophy, because he terms the ultimate unknown facts of structure 'Determinanten.' How often has science been impeded by the intru-

sion of a pedantry which mistakes the invention of a new term for the introduction of a new idea!

To find out what structure really is is the goal of all biological science. When we discover this secret, we may hope to discover also how structure functions and why it exists. The problem of structure—of organization—is double; there is first the question, what are the essential qualities of the structure of living matter as such, and there is, second, the question of the variations and specializations, which structure may undergo. With both of these questions embryology is confronted and both of them it is seeking to answer. The first is the riddle of life. Embryologists are bravely attacking it and have, I believe, already made a little real progress towards its solution. To them it presents itself as a series of queries concerning the germ-cells and the fertilized ovum. Searching analyses of the details with the highest powers of the microscope and the most refined technique coupled with experiments have indeed increased our knowledge of the organization of the germ cells. America, thanks to the brilliant work of E. B. Wilson and E. G. Conklin, and of their associates and followers, occupies a leading position in this difficult exploration. The importance of knowledge of the fundament of organic structure can hardly be exaggerated, and when it is obtained it will, I may prophecy, have profound far-reaching and enduring effects upon all medical science.

Even more intimately is embryology occupied with the second part of the problem of structure, namely, the question of differentiation, *i. e.*, of the gradual production of the varied organization of the adult with almost innumerable unlike parts. To-day the central problem of biology is that of differentiation, and the main purpose of cotemporary embryological research is to attack that problem. The problem is three-fold, for we must learn what differentiation is, how it is produced, and why it is produced. Embryology might almost be termed the science of organic differentiation. Now all that you do, as practising physicians, is to deal with differentiated organs and tissues. You deal with a function, normal or diseased, which is rendered possible by the differentiation of cells. You deal with pathological states, every one of which has its special differentiation. Every phenomenon which you encounter in your professional work is conditioned by the differentiation of the organic living substance. To regulate that differentiation, to set it right when it has gone wrong, is the brightest vision of future human power which I can conceive, and I can not but think of embryology, which strives unceasingly to discover the laws of differentiation, as that Institute of Medicine which is to be the foundation of a greater practical medical progress than any yet achieved. The physician's knowledge is the mother of mercy.

THE LARGEST AMERICAN COLLECTION OF METEORITES.

By L. P. GRATACAP, A.M.,
AMERICAN MUSEUM OF NATURAL HISTORY.

IT requires very little imagination to picture to our eyes the astonishment of the inhabitants of the older portions of the earth at the fall of meteorites in days before scientific knowledge had reduced them to ordinary phenomena. What could be better calculated to excite admiration and reverence than a luminous missile suddenly passing athwart the sky, accompanied by detonations, and almost simultaneously reaching the ground? Was it remarkable that superstition quickly enclosed them in its mesh of fable and fancy? Believing that the gods were accustomed to descend upon the earth, these visible apparitions of flame might not unnaturally seem to them the vehicles, or at least the portents, of their descent.

In fact, a series of interesting medals or coins struck off to commemorate these unusual visitations has been found amongst Roman and Grecian antiquities, which have been styled 'Betyl Medals,' from a supposed reference to the Hebrew 'El Bethel,' the house of God, thus implying that the meteorite was indeed, by contemporaries, regarded as a supernatural object.

Science and observation have long ago determined their cosmic nature, and while opinions may still vary as to their exact origin, their actual constitution is well understood, and their source, in extra-terrestrial streams of moving matter, recognized.

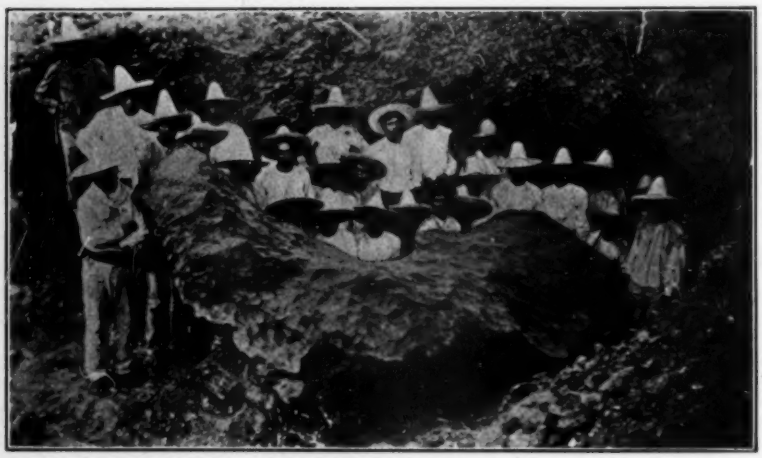
These strange objects have not diminished in interest because their miraculous origin has become a myth. On the contrary, science, by its exhaustive research, has placed them in the very front rank of objects that excite most vividly the imagination of the investigator. When science, in a perfectly rational way, speculates upon the possibility of one of these celestial visitors having passed through stellar space at measureless distances from our planet, exposed to inconceivable degrees of cold, and again at another time and place in its long transit to have encountered the most intense heat in the neighborhood of the sun, it requires little more suggestion to make it clear why they are to-day placed amongst the most prized specimens in mineralogical collections. The little further suggestion required to awaken the lay mind to a vivid realization of their interest is contained in the modern conception of their origin in dismembered comets, or even disrupted worlds.

Museums and individual collectors have vied with each other in

CUERNAVACA, MEXICO, SECTION OF IRON SHOWING FIGURES.

securing meteorites, and the details of falls, their date and locality, the comparison of types of meteorites, their mineralogical components and their many physical peculiarities have been so carefully recorded and studied that a special science has resulted, and a special group of students, whose rivalry is more animated than that generally discovered elsewhere amongst collectors of one kind of natural object.

The collection and the collector of meteorites have, with few exceptions, been features of the nineteenth century only. Previous to that these wonderful objects elicited surprise, and perhaps superstitious regard. Only within the nineteenth century did their careful comparison and study begin. All such collections as the great cabinets of Vienna, London, Paris, Berlin and the many smaller ones distributed through Europe have been slowly formed, the actual supply of material being dependent on meteorological incident and the results of travel and observation. In America, the larger collections at Yale, Harvard,



BACURBITO, SIDE VIEW.

Amherst and Washington were very gradually brought together. There was no concentrated effort made to extend them; the scientific thought of the last century, except towards its close, had not keenly awakened to a realization of the almost marvelous connotations implied in these strange aerial vagrants, and the opportunities for their discovery had not been actually availed of.

No one in the United States has exhibited greater perseverance and a more boundless, almost reckless, enthusiasm in this work of collecting meteorites than Professor Henry A. Ward. His audacity and zeal have gone hand in hand with a very keen scientific sense of the meaning of meteorites, and an admirable acquaintance with the literature and the results that have developed in their study.

He has himself been an explorer in this field, and it would be safe to predict his first arrival at the scene of any new meteorite's fall to-day. His correspondence is extensive, and the merest mention of a meteorite occurrence flies to his desk, and is very quickly subjected to his pertinacious system of verification or exposure.

The Ward-Coonley collection of meteorites now exhibited at the American Museum of Natural History represents his tireless work through many years, and stands to-day first amongst the collections of meteorites in this country. In the possession of large, unique masses, other collections may at points excel it, but in its representative character and in the actual number of 'falls,' it surpasses all others. The reader unacquainted with the peculiar pride of meteorite collectors may, perchance, welcome a little elucidation.

Meteorites are named from the locality in which they fall, or are found. But few meteorites have ever been seen to fall, and hence the meteorite mass, when discovered, is given a name (by which it is ever afterwards distinguished) that is derived from its exact locality or neighborhood. Thus Cañon Diablo, Arizona, Mincy Taney Co., Mo., Brenham, Kansas, Mocs, Transylvania, Estherville, Emmet Co., Iowa, are familiar labels in these collections. These designations sometimes of necessity assume a curious character, as the Vaca Muerta meteorite, or 'dead cow,' so named in the desert of Atacama, Chili, from its proximity to the corpse of that quadruped, the only, or at least a striking, physical feature in an otherwise featureless waste. Such a name remains after its origin has disappeared.

A certain number of localities, however, have frequently proved to be but representative of a prolonged fall. A meteorite mass, meeting the atmosphere of our earth, becomes, through friction, enormously heated, disruption takes place, and the separated parts, instead of falling at one spot, are dropped in succession at widely removed points, and thus a series of names becomes synonymous. Long examination and careful comparison, such, for instance, as Fletcher, of the British Museum, has

devoted to the Mexican falls, or Dr. Brezina, of Vienna, to those of Europe, only can correct erroneous nomenclature of this kind.

Again it is entailed, in the trials of a collector's work, to find some of his 'falls' spurious, that the specimens are illegitimate or are terrestrial; an accident which may awaken irreverence in the lay mind, but which has sent a shock—often salutary—throughout the community of 'star-gatherers.'

All falls or finds are recorded—generally in a description authoritatively made by the finder or a scientific acquaintance—and the objective goal to be reached by collectors is to have a representation of all such occurrences. Obviously size or weight is significant, and it is not

CUERNAVACA, MAIN MASS.

unnatural for a layman to insist upon the superiority of a smaller collection with handsome examples over a larger collection where the specimens are diminutive or insignificant. The masses of various localities differ also greatly in size, the amount of material falling varying enormously in different falls, and so the value of a particular kind of meteorite is conditioned upon its initial size. It is quite evident that a mass of one thousand grams will not admit of such attractive subdivision as one of five thousand, and, in the case of the Angra-dos-Reis aerolite, one of the rarest of meteorites, there is not enough to 'go round.' The Angra-dos-Reis unit also possesses peculiar lithological features, which naturally enhance the value given to it by its physical diminutiveness.

Colossal intruders from space, such as the Anighito, brought by Peary from Greenland and weighing (calculated) over forty tons, the Mexican Bacubirito of similar weight, and the large Chupaderos monster, weighing over fifteen tons, while easily distributed to collectors, will eventually weigh more significantly as unique features in their entireness in the museums destined to receive and install them.

It is desirable to call close attention to the admirable results of Professor Ward's labors, and to emphasize the preeminence the Ward-Coonley collection now takes in American cabinets.

Professor Ward has taken every possible pains to perfect and enlarge his collection. He has purchased and exchanged, and has traveled the world seeking almost inaccessible masses to obtain new examples. An instance of the latter was his exploit in reaching and

WILLAMETTE, LOWER SURFACES SHOWING CAVITIES DUE TO DECOMPOSITION.

unearthing the Bacubirito iron in Mexico, and a more recent venture in studying the anomalous features of the Willamette iron in Oregon under severe meteorological drawbacks.

This collection has been signalized by the most striking compliments from original workers and directors of museums in Europe. Professor Carl Klein, the state counselor and director of the Royal Mineral Collection at Berlin, has referred to it as 'one of the finest and richest meteorite collections in the entire world'; and Dr. Brezina, the most famous student of these objects, writes: "Professor Ward has succeeded in reaching the highest number of localities now united in any collection. I count up to this day 689 localities described or

mentioned, twelve of which are dubious for want of precise dates. From the remaining 677, I find 603 represented in his list, while the great Vienna collection gives but 557, counted in the same manner. The average weights are likewise highly satisfying, the total average, viz: the whole weight of the collection divided by the number of localities is over four kilograms (now 4,138 grams) for the locality."

This is the analysis of a technical expert, and might perhaps but poorly reflect the impressions of one less solicitous about percentages and exhaustiveness. The ocular view must be considered, the sensible visual effect of interest and wonder. In this respect the Ward-Coonley collection is eminently adequate to extort praise. It is now arranged in seven beautiful cases at the north end of the Hall of Geology at the American Museum of Natural History, and the specimens classified in their three groups of iron (Siderite), iron and stone (Siderolite), and stone (Aerolite), present their extended, yet thick and close ranges, most effectively to the spectator. Superb polished slabs, etched and developed, follow one another in the stepped series; and the bewildering number of aerolites, many large, and showing that invaluable and (to the eye of the collector) most exquisite test of certainty, the dark glistening crust of fusion, succeed, installed upon attractive mahogany standards; while a supplemental section of casts, reveals the original form and appearance of many celebrated or singular meteorites.

ONE OF THE SEVEN CASES CONTAINING THE WARD-COONLEY METEORITE COLLECTION, AMERICAN MUSEUM OF NATURAL HISTORY.

The assemblage is a striking and forcible tribute to Professor Ward's enthusiasm and persistency. A moment's reflection upon the order of events in the history of this great American collection of meteorites is not without interest. Professor Ward had been known as the indefatigable explorer of the continents and seas of the earth for all kinds of natural objects by which our American museums have so largely profited, but it was not until he had disposed of the great collection of natural history specimens which he exhibited at the International Exposition at Chicago in 1893 that he felt free to seize an individual field of study and enterprise. His mind had been deeply moved by the appeal made to it by these mute messengers from space, and a certain challenge offered by them to his ingenuity and skill to find and possess them. He gave himself over literally to this pursuit with a single-minded persistence that only success could reward. Professor Ward has played the part of *exchanger* to its fullest limits. In this he has acted upon a very acute design. In all large museums and with most active collectors, there are specimens that, as Professor Ward puts it, 'money could not dislodge.' Only the actual offer of pieces as rare, or more rare, and to which all approach was absolutely closed, except by the avenue of exchange, could displace them. Under such pressure Professor Ward has happily gathered into his possession many a piece of celestial iron or stone, which otherwise would have remained as immovable as Fitz-James before his less capable assailants.

N'GOUREMA METEORITE, SOUDAN, CENTRAL AFRICA. Fell June 15, 1900.

But practical and effective as has been exchange, as a means to an end, the infallible efficacy of money has been no less powerful. The actual expenditure has been very great, and in this pursuit, as in war, the cost for a successful issue must not be counted. Professor Ward enjoyed two unusual opportunities for suddenly increasing the size of his collection. The Gregory collection in England and the Siemaschko collection in Russia, vying with each other as the largest private collections in Europe, fell into his hands at the death of their owners, and

from these treasuries he filled the gaps, and enriched the precious contents of his own. His collection is one of increasingly rapid growth, and illustrates the quantitative results of single-minded effort, precision of attack at vulnerable points and prodigality of purchasing power in a scientific warfare where the victor only receives the congratulations of his generous competitors.

Looking over Professor Ward's recently published catalogue, some concluding facts in this summary are interesting and convincing. In an introductory paragraph of his catalogue (1904) the author says: "The geographic sources of the collection are world-wide. Australasia and Asia, Africa and South America, are represented each by 95 per cent. of all their known meteorites, while North America and Europe bring up the train with 99 per cent. of the former and 97 per cent. of the latter. No collection in the world can say of itself more than this. Attention is particularly drawn to the series from Japan, Australia, Russia and Mexico. It is only within the last decade that the rare and interesting meteorites from these countries have been largely distributed. To-day it is true that in no collection in any one of these four countries are there so many kinds from that country as are represented in this collection." The catalogue further notices that in this remarkable collection thirty falls, irons and stones, represent the largest single piece of that fall to-day known.

The final impression left from an inspection of the Ward-Coonley collection is one of admiration and of natural astonishment that so complete an assemblage of these valuable and coveted wanderers from space could have been gathered together by the activity and industry of one individual. Their acquisition places the institution that receives them among the four most important meteorite depositories in the world.

SUMMARY OF THE COLLECTION.

Total number of falls and finds	603
(Siderites 241; Siderolites 28; Aerolites 334.	
From North America	229
From South America	31
From Europe	231
From Asia	77
From Africa	27
From Australasia, Sandwich Islands	26

Total weight of entire collection 2,495,429 grams (=5,509 pounds).

Average weight of each kind 4,138 grams (=9 1/9 pounds).

Average weight, counting nothing over 50 kilograms to a kind, 1,746 grams (=3 4/5 pounds).

Total number of specimens, about 1,600.

THE PLANE OF ETHER

(Being Further Extracts from the Records of the Astral Camera Club of Alcalde)

By President DAVID STARR JORDAN

STANFORD UNIVERSITY

AT the December meeting of the Astral Camera Club, through the courtesy of Madame Yda Hhatch, of San Diego, vice-president of the American Chirological Society, the club received a rare treat, direct from the fountains of the Orient.

Madame Hhatch is an adept in the science of palmistry and therefore a person of wealth and culture. She is pleased to exercise her gracious prerogative of patronage to scholars of all lands and of all beliefs. By her kindly interest the club was favored with an address by the Swami Ram Telang, of Bombay, from the Congress of Religions in Chicago, the substance of which, omitting the Hindu words I can not understand, I shall try to transfer to these records.

The Swami Ram Telang is a slender, dark-skinned Brahmin, with a delicate moustache and a complexion of varnished leather. His finely cut mouth bears an impress of sweet patience, while his dark soulful eyes have a deep inward expression, as though earthly matters were but a veil, half hiding the light of the inner vision. He wore a white turban after the manner of his class, and his white and purple robes were very becoming to his gentle but manly figure. Madame Hhatch impressed upon us the importance of refraining from all contact with these robes, for a profane touch would soil his aura, besides impressing the severest pain upon his sensitive Nirvanic nature. For like reason he must be sheltered from the odor of cooked meat, while even the slightest approach to a butcher's shop on the street caused him the nausea and shudders. As he himself confessed, the perfection of being which he had attained was not an unmixed blessing, for the proofs of sorrow and suffering were ever in his sight. "Why hast thou cast Ram," he said sometimes to his Lords of Karma, "into the time of the ever-blind to proclaim thine oracles with the opened sense?" But he was very kind withal and very patient and accepted with kindness our offerings of adulation.

In this, my report, I can do but scant justice to his spoken words, for though I am not without literary taste and facility (though I say this, who should not) there was something in the lofty ideas and perfect

expression in the measured words of this gifted young Brahmin which is beyond any effort of mine.

He began by an account of the five usually accepted planes of existence, the physical, the astral, the devachanic, the shushuptic and the nirvanic. But to limit these planes to five was, he said, 'a great error,' introduced into our philosophy by the too practical British mind which even in esoteric matters is crowding to the wall the finer understanding of the Hindu. The sole perfect number is seven and there must be seven planes and in his own experience as a wayfarer to Devachan and Shushup, he had always and ever found it so. Above the astral plane, already familiar to us at Alcalde lay the etheric plane, as the ether lies beyond the stars, while still beyond is the omnic plane, the Loka of the Perfect Silence.

Of the etheric plane, he chose to speak to us. He first emphasized the fact that all these planes and the things they contained are real, 'as real,' he said, 'as the American Hotel on the main street of Alcalde.' As all dreams came from emanations or excursions into these higher planes, all dreams and their contents are real also. In fact, there is no apparition which is false or illusory. The only illusion is the denial, and denial is the essential characteristic of that western philosophy, which is blighting the earth and changing it from a sphere of dreams and happiness to a world of war and commerce washed by a sea of aimless discontent. This is the natural effect of life on a physical plane. It leads to idle strife and constant struggle, as its greatest exponents have freely admitted, and its only hope of progress is in the killing off of all those who are useless in war and unskillful in making trades.

The scenery, inhabitants and actions in each of these seven planes are in part peculiar, each to its plane. In part they are the doubles or phantoms of the objects found in the plane next lower. For the finer matter of the higher planes permeates and penetrates the coarser objects of the planes below. Hence it transpires that to one in the plane below, the higher object, if he is aware of it, seems like a shadow or a phantom. Because he can pass through it is his argument for its unreality. But in like measure, to the astral or ethereal being the physical man seems quite as unreal, for with equal ease the being can walk through and through him, injuring him or helping him, just as he may elect to choose. By such means an evil-minded shadow may work dire revenge for injury done in another plane.

The higher the plane the more illusory the impressions we derive from it, not because of their unreality, but because of our own lack of training. For on the higher planes, objects change their forms with protean swiftness, casting a dazzling glamour from their aura as they change; again, sight on the higher plane is very unlike physical vision. Even so low as the astral plane the inside of any solid object is as

plainly open to the eye from the outside, and all objects near or far are seen alike without perspective. The fourth dimension, the dream of geometry, is plainly visible and in the omnic plane is clearly seen a fifth or sixth dimension. With these chances for error, it is not strange that the Feringhi, or English writers, on the higher planes have made frequent errors, while even the Hindu adept is never quite infallible. As a preparation for such investigation crystal-gazing has been found desirable. Still better is the formation of circles of silence when men and women gather around a white lily or other creation of purity and beauty and, clasping one another by the hand, endeavor to think Ether and Om. After many years of these exercises, gathering around perfect objects under his direction, the Swami said, a few devoted women had even risen to think Devachan and Shushup. No Englishman had, however, come to this and in our Caucasian race not even a woman of English birth had ever been able to think Nirvana. For in Shushup all desire to act is lost, as in Om is all desire of speech. In Nirvana alone is the absolute extinction of all desire—a thing impossible to you Americans.

The scenery of the etheric plane is much as in the physical existence, only more wavering, more delicate, more enchanting. Its objects of fine matter, finer than anything in the atomic or molecular way, freely interpenetrate all merely physical matters. It is therefore not necessary to seek it far from home. In India and Thibet, this scenery is peopled with its multitudes of beings, for these are the oldest lands of man, peopled for ages with him and his creations. California, on the other hand, with the exception of a few areas, as Point Loma and Chinatown, is virgin soil in its astral and ethereal aspects, its sole abundant life being the nature emanations and the essential spirits of animals. One may wander in its verdant etheric shades for weeks and never encounter a human creature. When one meets such a being there on the etheric plane, she is most gracious and friendly, her company a welcome recompense for months of loneliness. The appearance of a friend in these wastes is signalized by the glimmer of his aura which, as a most learned occidental adept has pointed out, appears "as an oval mass of luminous mist of highly complex structure, from its shape sometimes called the Auric Egg." This writer maintains with apparent truth that these auras are not mere emanations but the actual manifestation of the ego on their respective planes. "It is," he says, "the auric egg which is the real man, not the physical body which on this plane crystallizes in the middle of it." This is certainly clear if we keep in mind the difference between this ego-aura and the physical health-aura which is the first purely astral object seen by the untrained and seldom enters the etheric plane. For the sake of clearness we should call the contents of the auric egg the 'etheric double,' which is merely a new name for a very old idea, for it has long been

known that the mold on which the physical body is made up is held in perpetuity by the agents of the Lords of Karma. Thus, however complicated and unusual a man's Karma may be, these agents, or Lipika, are able to give a mold in accordance with which a body exactly suiting it can be formed.

The inhabitants of the etheric plane are as varied as those of the astral and physical planes, with this distinction, that certain types and races of men never rise above the last-mentioned level. For example, English is scarcely spoken on the astral plane and never on the etheric, where for most part is heard only some form or derivation of the Sanscrit. Those who aim to make of the bluntly practical English a universal tongue must soon see the futility of such efforts. For a language which barely reaches the astral plane can never be universal, while at the upper limit of Devachan, as is well known, all language disappears. Only the Voice of the Silences, the vibrations of the perfect Om, the one word which closes the lips whenever it is spoken, is heard in the Crystal Vaults Superior.

The learned Swami proceeded to divide the inhabitants of the etheric plane into seven great classes, for the sacred number seven is involved in all these investigations. These are (using our inadequate English words): (1) The embodied, (2) the bodiless, (3) the shells, (4) the incubi, (5) the extra-planetary visitors, (6) the essences, (7) the artificials.

Those of the first class, or embodied entities, have bodies on earth, still engaged in operations on the physical plane. These may be adepts or Chilas, or they may be canny yogis, or Initiates, possessed of second sight, or again ordinary men fast asleep at home, whose etheric doubles are drifting about involuntarily, swayed through esoteric currents, or the so-called 'winds of dreamland' of your western mythology, or finally they may be magicians, white or black, seeking their own ends, some of them unfortunately evil. The investigator may meet also on this plane students of the invisible, quite unconnected with the great master and knowing nothing of the mahatmas. These men, Slavs, Lapps or Malays, are often most earnest and self-renouncing seekers after truth, and the wise wanderer on the etheric plane will greet them with the omnic kiss of esoteric brotherhood.

Of the bodiless class are likewise many, some of whom have wandered from afar. Even from Nirvana, perfect souls have descended, creating for themselves a perfect ethereal body for the purpose, since the more refined vesture of Nirvana would be invisible to ethereal sight. These souls never attempt anything in these lower planes, for in Nirvana is the final quenching of desire. Here too, the ego of adepts may await reincarnation, an unusual mode of procedure, it is true, but sometimes to the self-renounced such favor is granted by the great master of reincarnation, Gautama-Buddha himself. But here the greatest care is

necessary while the matter is arranged, lest by a touch of the Devachanic plane the waiting ego be swept by irresistible current into the line of normal evolution. In some cases, to avoid this strange accident, incomprehensible to you who have never left the limits of Alcalde, and to escape the trouble of a new birth, with the pains of teething and the other woes of childhood, the adept will enter some adult body, abandoned temporarily or permanently by its former tenant. The advantages of remaining bodiless are, however, considerable, as this avoids the hampering possibility of fatigue while retaining perfect consciousness. The disadvantage is that as nothing can touch the being in question, it can touch nothing for itself. Here, too, gather many of those who have abandoned the physical life, to be returned to it, in reincarnation, not having perfectly achieved higher possibilities. Most of these remain, however, on the astral plane, never falling below the density of shades.

The third class, known as 'shells,' are soulless bundles of qualities fastened together by will or thought and so retaining a human resemblance though all vestige of humanity has departed. Such, when seen by the canny, are recognized as ghosts. In writings of adepts you will find accounts of psychically developed persons, that is, persons possessed of second sight, who have seen about cemeteries 'hundreds of these bluish-white misty forms, hovering over the graves where are laid the physical vestures which they have recently left.' These shells may be galvanized into a very horrible form of temporary life, but this is only done by the loathsome rites of one of the worst forms of the black magic, which you of Alcalde, most of you not even initiates, much less adepts, could never be made to understand.

Still more unpleasant are the incubi, or clusters of wicked qualities, wrenched by violence from their possessors as a stone is torn from an unripe fruit. These take a fiendish delight in exercising the arts of delusion which the higher plane puts in their power to lead others to the excesses which proved fatal to themselves. For such a one to meet a medium with whom it is in affinity is indeed terrible, for by such means its existence may be indefinitely prolonged. Still worse are the vampire and the were-wolf, which we of the Fifth Root Race now seldom encounter, but which, to Slavic and Germanic adepts of the earlier centuries were objects of fear and danger in the astral regions and even as high upward as Devachan. All these are human in their origin. Not so the fifth class, the occasional visitors from other planets. Of these wonderful creatures we know nothing, for only the highest of high adepts have the power of moving from planet to planet, and even I do not understand how it is performed. When these visitors appear, they choose a body temporarily created out of unused ethereal matter belonging to the earth. Over this they wear a distinctive badge, a ring indicating Saturn, a series of belts indicating Jupiter or a tiny flaming

spear and shield for Mars and a silver mirror in a golden necklace for Venus. In Shushup, it is said, guests for all the signs of the zodiac are received—but of these I have seen but two, a charming young lady from Virgo and a mahatma from Sirius who bore the badge of a great dog or wolf.

The sixth class are elemental essences. These may be either mineral or monadic in their nature, this depending on their origin. Usually they begin as a thought, aspiration or association of ideas, permeated by its appropriate variety of the deva or life principle, hence capable of floating or drifting about through etheric or astral space, until at last crystallized as an ego and embodied as a man. The history of these monadic essences is still obscurely known, as few adepts have the patience to watch them continuously through their centuries of development and incarnation. These often pass through the stage of animal essentials, some of whom are at last incarnated as animals, and the learned author of the 'Secret Doctrine' describes his encounter with a number of these essences 'embodied in anthropoid apes, already individualized and ready to take human incarnation at the next round or even sooner.'

Then in the etheric plane are swarms of nature spirits, the tiny emanations of the sunny banks of moss, the foamy waterfall or the fragrance of the roses. Some of these are dim and gigantic, the products of the mighty cañon, the roar of the sea, or the awesomeness of the forest. These may assume all forms at will, but when at rest they take the shape that is most befitting their natures. Ordinarily they are out of human sight, but they have the power of self-materialization, or they can be formed into visual clearness by the effort of a powerful will. Such essentials are known to us of the east as djinns and sprites and peris, but in the west they have many names, fairies, gnomes, elves and imps, and the Greeks called them fauns and satyrs. Those which live in water are called undines, those which live in air are sylphs and those in fire are salamanders. The wild essential spirits do not like the presence of man, though they often try to help him or sometimes to play little tricks on him for their own amusement. They have no real dislike for humanity, but the constant rush of astral currents set up by the restless ill-regulated desires of Europeans disturbs and annoys them. In India, they are more at ease and lie about under the palms and the bulbul trees. In Olcott Sahib's beautiful gardens in Madras, Ram has spent many joyous evenings in commune with them. Similar creatures are ever present in California, giving your state the indescribable charm of which you all talk so much and feel so little. In a quiet stroll in the woods near Alcalde with Madame Hhatch, Ram found them in myriads, some of them lurking in the branches of the eucalyptus trees, others had burrowed in the dry ground to form fairy homes. In Ram's visit to Angels he found them thick under Abner

Dean's great pines. Around the abandoned mining shafts there were other essentials of an evil disposition with an unpleasant smell of sulphur which suggested human origin. When examined and unrolled by means known to initiates, these sprites were found to be mere bundles of oaths held together by the force of spent passions and evaporate spirits of rye. The highest of these essentials or non-human entities is the deva, a superhuman essence destined to become man, but which has remained fixed for a time in an intermediate or higher stage. Such creatures, according to the common expression in Devachan, 'have yielded to the temptation to become a god.' No blame attaches to this expression. The path to incarnation thus selected is not the shortest one, but it is a very noble one, and for some not yet well tempered for humanity it is the one best suited to their natures. It is of course impossible at this stage of our striving to tell when we shall have earned the right to choose our own future. We should not, at any rate, before we ourselves reach Devachan, be too ready to despise those who have never seen fit to drop below that level. These devas are the winged globes and fiery wheels of our secret doctrine. There must of course be seven classes of these as there are seven of nature spirits and seven of elemental essences. For each class there must be a devarajah or king of devas, seven in all, but outside the circle of initiation, little is known and less must be said of the higher three. The four we know are called, respectively, the north, south, east and west wind, or the kings of earth, air, water and fire, clad, respectively in green, yellow, blue and red. These words and garments are symbols only telling nothing of their names or duties. These are inner mysteries of the White Mahatmas, unknown even to the Black Magicians, or to the seers of djinns and wraiths.

The last, or seventh, class of etheric entities is by far the most important to man. The artificials are man-created and by their return influence they make and unmake man. To this class belong the creations of the poet, undying and tangible in proportion to the poet's creative power. In this class too are all good wishes and all anathemas, all hopes, fears, faiths, creeds, and embodied loves and hates. All these find in time a living shape felt or seen by all canny psychic children in the flesh, a menace or a shield not limited by space or time. Elementals of this shape are often utilized in the 'sendings' of living objects transmitted invisible through space for the delight of a friend or the confusion of a foe. To this class belongs the white bird of the Oxenhams, whose appearance ever since the time of Queen Elizabeth is a sure presage of the death of some member of the family. In the noble family of the Whistlehursts a spectral coach drives up to the castle gate calling 'What, ho!', whenever a similar calamity is impending. Strains of wild music, the policeman's rattle, the blood-curdling shriek of a trampled cat, the clank of chains, all these are familiar to those who

have looked into the phenomena of haunted houses. These elemental artificials are embodiments of man's will and thought. Once wrought together by longing, fear or crime, they may last for ages. An elemental, it has been wisely said, is a perfect storage battery from which there is practically no leakage. After a thousand years, a conception carefully worked out and firmly wrought together exhibits unimpaired vitality. In a famous case, such an artificial still warns the direct descendents of Sir Godfrey de Gespensterheim of their approaching doom by repeating in their ears the strange wailing music which was the dirge of his beloved son, Sir Lienhardt, seven hundred years ago in Palestine.

When these artificials are formed consciously and purposely they may be made the engines of tremendous power. Occultists of both the white and the black schools use them frequently and no influence in all the psychical universe can be so potent. But the evil use is not so common as it would be were it not that the highest occult power is granted only to the virtuous, and the black magicians are often torn to pieces by fiends of their own raising. Thus cast back into Devachan, their former power is lost to them and their reincarnation as dogs or monkeys by way of purification is extremely probable. This accounts for the multitudes of these animals in the streets of Benares and Constantinople. It is their nature to haunt the scenes of their physical exploits. To make artificials of extreme virulence and power has been the work of the sect known as the Lords of the Dark Face. Among other things they formed 'wonderful speaking animals who had to be quieted by an offering of blood lest they should awaken their masters and warn them of impending destruction.' From creatures of this type, created for a special purpose and afterwards neglected by an overworked magician, the race of parrots is descended. The devotees of the ghostly goddess Kale once performed rites too horrid to describe, and the results of which were the submergence of the continent of Lemuria with the loss of sixty-five million, two hundred and eighty-five thousand human lives, besides several myriads of promising anthropoids only lately condensed from Devachan. Even Ram, a mere Swami who has been in Nirvana only as a mahatma's honored guest, could speak a word which could blast your mountains, blight your fruit or growing grain or flood your valley with the waters of the sea. Such mystic words there be and Ram knows them. Ram's finger could point unerringly to the limitless fountains of gold in your hills. But Ram stays his voice and withholds his hand, for his life is a life of meekness and self-renunciation and these things must not be.

It is in the formation of artificials that a man's real character appears, whether on the physical earth or in Astrum or Devachan. The true adept forswears all that may be harmful to others. He may not use his power for his own advancement, hence his vow of poverty

is for the protection of his soul. Having no selfish end in view he is ready to believe and to worship. To the western mind, belief and worship are as yet undreamed of. Instead of the silence of Om and the perfect rest of Nirvana, you hope for more business, more action, more pain, more unrest. The physical plane is the goal of life and the six planes above it are valueless assets of dreamland, unless they can be laid out into city lots. Turn your faces to the East, O Europeans, and learn of the patient, restful millions whose dreams, daily and nightly, bring more truth than all your struggles and your science of two thousand years. The religion of the West has long since lost its hold on thoughtful men and soulful women. The only reality in your lives is pain. The light of your old altar-fires is growing dim and when again it is relighted it must be in the name of the master of renunciation whose servant and follower you behold in me. It shall be for the worship of the suffering unconscious to whom pain and pleasure are dreams alike, mere floating shadows which dim for the moment the perfect serenity of perfected being.

After the conclusion of this passage, Madame Hhatch asked the privilege of a final word. She spoke of the learned Swami so far from his home and drew a pathetic picture of his life of renunciation and his vow of poverty. His heart yearns for Bombay and the light of his own altar-fires where the sweet sandalwood burns in its temples of perfection, which are symbolized in the mouth-closing word Om. Yet he is forced to earn his bread on the other side of the earth teaching people who can not understand him and whose every contact raises blisters on his astral skin. It is our duty to open the way to his return to that which is dearer to him than life.

So at the instance of Mr. Abram Gridley, the schoolmaster, we took up a generous collection which the young Brahmin received in patient silence.

As he passed out, Miss Violet Dreeme, of Fidèletown, who is a poetess and suspected of jealousy toward Madame Hhatch, uttered the sole syllable of discord. "I read every word of that," she said, "in one of Mrs. Tingley's little books of Hindu Poetry." This Swami is the very man who was at the Midwinter Fair out at Golden Gate Park. He etches your portraits on cardboard with his fingers while you wait and he cheated me with a bad half-dollar. Why, Madame Silva, who told fortunes in the next booth, says that he got a reporter for the San Francisco *Clarion* to write this speech, and it was a whole month before he had it learned so that he could go through it straight.

"The fact is, I am told, the Hindu in America has but one article of faith. More precious than rubies is the woman of leisure seeking for a new religion. The real 'Secret Doctrine of the Brahmins' is this: 'So beg that you will seem rather to grant than to receive a favor.'"

ARE THE ELEMENTS TRANSMUTABLE, THE ATOMS DIVISIBLE AND FORMS OF MATTER BUT MODES OF MOTION?

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THE advance workers in chemistry and physics are constantly accumulating new facts and propounding new theories which must be digested and incorporated in the body of the sciences. The process of assimilation is often slow, and it is right that new and important facts should be vouched for by more than one investigator, and that a new theory should prove its usefulness before being placed beside old and tried facts and theories. But too often the effects of the advances are unduly delayed through a reluctance to revise old text-books or old lectures, perhaps not so much because of mere laziness, as because of a failure to appreciate the full force of the evidence in favor of new views, or of the advantages to be obtained by their adoption. The fact that the arguments for an innovation, for a time at least, are scattered through many journals, leads to an underestimate of their cumulative force.

It is the purpose of this article to gather the main facts, some old, many recent, most of them fairly generally known, which are compelling us to alter our old definitions, and to show what a strong argument they make in favor of believing in the transmutation of the elements, the divisibility of the atoms and that what we call matter is simply a mode of motion.

It is interesting to note the caution with which text-books express themselves when it is necessary to give definitions for these terms. By a careful choice of words most authors avoid making false statements, but they certainly do frequently lead their readers to unjustifiable conclusions. For instance, in Roscoe and Schorlemmer's 'Treatise on Chemistry,' issued in 1891, we find the definition, 'An atom is the smallest portion of matter which can enter into a chemical compound.' As is the usual custom, the ideas of the alchemists regarding the possibility of transmuting metals is held up to ridicule, and thus, by implication at least, the ultimate nature of the elements and the idea that the atom is indivisible are infallibly conveyed to the reader. A more recent instance is to be found even in the late editions of one of the most widely used texts on general inorganic chemistry. In this book, on page 4, we read, 'Molecules may be defined as the smallest particles of matter which can exist in the free state'; on page 5, 'Atoms are the smallest particles of matter which can take part in a

chemical change'; on page 6, 'Molecules consisting of atoms of the same kind are termed elementary molecules, and substances whose molecules are so constituted are known as elements.' The numbers of the pages on which these statements occur are also significant. This reminds one of the methods of the old Greek philosophers, who pretended to solve all questions of science by pure deduction, positing some hypothesis, and then developing everything else by meditation in their closets, disdaining to disturb the order of their thoughts by experiments. But it is unworthy of the present age of inductive science, wherein every thought has, or should have, experimental evidence as its starting point. It can not be said that this particular author has made a false statement, but he has left the subject incomplete; cautiously reserving a loophole for his own escape, he fairly traps his readers. For it is inevitable that, with such didactic phraseology, and without having his attention called to the hypothetical, the tentative, nature of these definitions, the student should become convinced that the most fundamental facts of chemistry are that there are about eighty substances so simple that they can never be broken up into simpler things, and that all substances are composed of ultimate particles, called atoms, eternally indivisible.

A student started out with this hodgepodge of fact and theory thoroughly implanted in his mind as the basis for all his future knowledge is sadly handicapped, indeed he is intellectually maimed, and it may take him years to overcome the habit of confusing fact and theory, and to learn how to think straight; perhaps he never succeeds in overcoming it. This confusing of facts with theories is a vicious habit, which grows till it colors all one's thoughts, hinders the free play of the intellect, diminishes the power of right judgment and starts the ossification of the wits even before the age set by Dr. Osler.

It is not necessary to consider a student of chemistry as an infant in arms to be fed on predigested food. He may be assumed to have a digestive apparatus of his own. Give him the benefit of any doubt and ascribe to him at least a dawning intelligence, which, properly stimulated, may some day shed some light of its own. It is the characteristic course of a lazy teacher, and one pleasing to lazy students as well, to supply a lot of personal opinions in the shape of cut and dried definitions, so easy to memorize and, unfortunately, so hard to forget; phrases which do not require the intellect to bestir itself and exercise its faculty of criticism, to pass judgment for itself between alternative or conflicting views. Strictly speaking, nothing should be presented in the form of a definition except what is, in itself, a statement of experimental facts, as, for instance, we describe or define a unit of measurement in terms of other units. When dealing with a subject where more than one opinion is permissible, all should be stated, or at

least the attention should be directed to the fact that others draw different conclusions from the same premises.

The average student is better able to face issues and weigh arguments than most of us realize, and it is more important to educate those falling below the average in this particular than in any other. We should state the facts and then reason in such a way as to teach students how to think. It is indispensable for them to learn to think for themselves. Great stores of chemical facts are of but little real use, unless accompanied by an ability to adapt and to apply them in new conditions, unforeseen by either teacher or student in school or university days, but surely coming in after life. It is the prime necessity for research work or for originality of any kind, and we all are willing to admit that originality is what should be cultivated.

There is a great difference between the phrases, 'elements are substances which can not be broken up' and 'elements are substances which we have not as yet succeeded in breaking up'; and we should mark well the difference. This caution, lest we slip into the error of stating as fact more than we really know, is the distinguishing difference between the chemistry of to-day and the chemistry of a few years ago. It is more than this, it expresses concisely the difference between the way in which any science should be taught and studied, and the way in which it should be neither taught nor studied.

This particular differentiation between two definitions of the term element has been more than justified by the results which have followed the last ten years' work in pure chemistry, spectroscopy, radioactivity and Röntgenology (a term which has been seriously proposed by one of that fraternity which seems to consider its main function in life to be the coinage of new words).

The main arguments which may be marshaled in favor of considering the elements as ultimates, and the atoms as indivisible consist:

First, of all those facts which Dalton condensed into the laws of definite and multiple proportions, and to which there have been as many additions as there have been analyses and syntheses made before or since his time.

Second, Dulong and Petit's law that the atomic heats of all solid elements are the same.

Third, the isomorphism of many compounds containing similar elements, a phenomenon discovered by Mitscherlich.

Fourth, Faraday's law, that equivalent quantities of the elements are deposited at the electrodes during electrolysis.

Truly, an imposing array of evidence, and more than sufficient to justify us in making the assumption that atoms exist. But curiously enough, there is not one item amongst all these facts compelling us to believe that these atoms are the ultimate constituents, or that they are indivisible. These latter hypotheses are purely gratuitous, tacked on

by Dalton and retained by succeeding chemists and physicists for no good reason. Perhaps because imitation is a characteristic inherited from our simian ancestry, and is so much easier for us than originality.

Many a chemist looks askance at any tampering with the atoms, apparently fearing that it may hurt them, or even destroy them utterly and the atomic weights with them. Or he trembles for his spidery and tenuous structural formulæ, knowing full well that if deprived of these he will be irretrievably lost in a labyrinth, without a thread to guide him. While, if he is not permitted to think of the carbon atom as a little chunk of matter, tetrahedral in form, he thinks he is launched on a sea of troubles.

But all this apprehension arises from a misunderstanding. That the atomic weights remain unharmed and unaltered, as the units for chemical calculations, and that nothing which is good or useful about the atomic theory is destroyed or even assailed by the new ideas, that the trend of these new ideas is unmistakably constructive and not destructive, are best shown by a review of the arguments in favor of the hypothesis that the atom is divisible, and that our elements are not elements in the true sense of the word.

There is nothing new in this view; it formed the first article of the faith of the alchemists. It was unqualifiedly denied by Dalton, and fell into such disrepute that even within recent years one risked being called a dreamer, or even a fool, if he dared to consider it possible. Here again is an instance of the desirability of being as precise as possible in the use of terms. Many believe experimental evidence of the complexity of 'elementary atoms' and the existence of one 'mother substance' must be followed immediately by directions for transforming elements into one another; by the transmutation of baser metals into gold. But these are two wholly distinct propositions. An astronomer might locate a mountain of gold on the surface of the moon, but there would still be a goodly chasm to bridge before he derived much material benefit from his discovery!

The idea that there is one fundamental substance would not down. The hypothesis of the English physician, Prout, is a familiar one. When the atomic weight of hydrogen is set equal to unity, the atomic weights of all the other elements come out remarkably close to whole numbers. There exist numerous groups of three elements, commonly called Döbereiner's triads, the individual members of one group being similar in their chemical properties, and so related that the atomic weight of the middle member is the arithmetic mean of the atomic weights of the extreme members. These are the facts which led Prout to suggest that there was but one element, namely, hydrogen, the others being complexes containing different quantities of this ultimate substance. It followed that the differences between the atomic weights and whole numbers were to be ascribed to experimental errors in the

determination of these values. The desire to test this hypothesis was one of the chief motives for some of the most careful determinations of atomic weights which have ever been made. These determinations resulted in proving that the divergences of the atomic weights from whole numbers were greater than could be accounted for on the basis of experimental errors. This precluded the possibility that the atom of hydrogen was the common ultimate unit, but did not dispose of the possibility that a half, or quarter, or some other fraction, of the hydrogen atom might play that rôle.

In 1901 Strutt[1] applied the mathematical methods of the theory of probabilities to the most accurately determined atomic weights, and calculated that the chance that they should fall as close to whole numbers as they do was only one in one thousand. The inference from this is that it is not a matter of chance, but that there is a regularity in the atomic weights which we do not understand; a regularity which points to the probability that our elements are complex substances, constructed according to some system, from some simpler substance.

All the facts comprised in that great generalization, the periodic law, which states that the properties of the elements, both chemical and physical, are functions of their atomic weights, and most of them are periodic functions, point unmistakably to the same conclusion.

The evidence from spectroscopic analysis is so abundant that it is not easy to compress it into a few general statements.

In the first place, the spectrum of each of our elements consists of numerous lines, a fact not exactly compatible with the notion of extreme simplicity of the particles emitting the light.

In the second place, one and the same element, contrary to common belief, frequently has two or three distinctly different spectra, the particular spectrum which appears depending upon the pressure and the temperature at which the element is while emitting the light. In fact the extraordinary spectroscopic results obtained when highly rarefied gases enclosed in tubes (variously called Plücker, Hittorf, Geissler or Crookes tubes) were made luminous by the passage of high potential electricity, induced Crookes to suggest in 1887 a theory that the elements were all built up by gradual condensation with falling temperature from a fundamental substance to which he gave the name protyl.[2]

In the third place, the lines in the spectrum of one element may be separated out into several series. Each line corresponds, as is well known, to light of a definite wave length. The wave lengths of the lines comprised in one series are related to each other in such a way that a general formula may be derived for them. This means that, given some of the lines, the wave lengths, and thus the positions, of

[1] R. J. Strutt, *Philosophical Magazine*, March, 1901, p. 311.

[2] 'The Genesis of the Elements,' W. Crookes.

other lines belonging in the same series may be calculated. In this way the positions of certain lines for certain elements were foretold. Search failed to reveal all of them in light emitted by the element at any temperature producible in the laboratory. But some of the missing lines have been found in the spectra of the hottest stars, stars far hotter than our sun. At the same time many of the lines obtained by terrestrial means are lacking in the spectra of these stars. We have ample experimental evidence that many complex substances dissociate, as we call it, into less complex substances within the temperature range readily controlled in the laboratory. The inference is right at hand that at extreme, at stellar, temperatures our elements themselves are dissociated into simpler substances. To these substances, our elements, in this other condition, have been given their customary names, but with the prefix proto. Thanks to the introduction of Rowland's diffraction gratings for the study of these spectra, we have observations indicating the existence of proto hydrogen, proto calcium, proto magnesium, proto iron and so on through a list of a dozen or more 'proto' elements.[3]

Continuation of the work upon which Crookes was engaged resulted in the discovery of the X-rays by Röntgen in 1895. This date may be said to mark a new era in many of our conceptions regarding the universe about us. To J. J. Thomson, professor of physics at Cambridge, England, we owe the greater part of our present knowledge of the cathode rays. He devised most of the experiments and the ingenious, but strictly logical, reasoning which justify us in supposing that these cathode rays consist of swarms of minute particles, which he called corpuscles (reviving an old term and an old theory of Isaac Newton's); particles moving with velocities approaching that of light, each one carrying a charge of what we call negative electricity. He, and those working with him, determined the quantity of this electrical charge to be the same on each corpuscle, and to be the same as the charge we have good reason to suppose is carried by any monovalent ion in solution. By several methods the approximate number of these particles in a given volume and the weight of the individual particle were estimated. This weight appears to be about one eight-hundredth of the weight generally ascribed to the hydrogen atom, the lightest of all the atoms. It may be objected that there is no positive proof of the existence of these corpuscles, nor do we know the weight or mass of one of them. That is very true, but neither have we positive proof of the existence of atoms, nor do we know the weight of one atom. We can only say that the evidence makes the existence of these minute individuals, atoms and corpuscles extremely plausible, and makes one as plausible as the other.

[3] The methods, facts and reasonings relating to this spectroscopic evidence are interestingly given in 'Inorganic Evolution' by Sir Norman Lockyer.

Grant that we have discovered particles—in round numbers one thousandth part the size and weight of the hydrogen atom—the argument is still not complete for the divisibility of the atom. Perhaps we have found a new element. But cathode rays were produced under circumstances where they must have arisen from the cathode itself, and it is hard to escape from the conclusion that the atoms of the cathode disintegrated to a certain extent to furnish these particles. Furthermore, rays have been studied having as their sources different metals under the influence of electrical currents, different metals heated to incandescence, flames of different kinds and ultra-violet light; and these rays appear to consist of corpuscles of the same weight, no matter what their source. This makes it difficult to escape from the further conclusion that atoms of a great variety of natures are capable of disintegrating and of furnishing the same product by the disintegration;[4] and this is as much as to say that instead of about eighty different elements we have one 'mother substance,' and Prout's hypothesis is once more very much alive, somewhat modified, it is true, and in a new garb, better suited to the present fashions.

It remains to rehearse briefly the evidence to be obtained from radio-active phenomena. In the first place, the rays incessantly sent out from these extraordinary substances consist, at least in part, of rays like the cathode rays, and are streams of the same kind of corpuscles, but, on the whole, traveling with greater velocities than the corpuscles of the cathode rays. It has been proved by Rutherford and Soddy that the emission of the radiations from these substances is accompanied by a disintegration, or decay, as they describe it, of the substances themselves. These investigators have caught some of the products of this decay and have studied their properties. These products themselves decay, some slowly, some rapidly, sending forth other rays and furnishing new products to decay in turn. Indeed each new issue of a scientific journal for the past few years seems to chronicle the birth, life and death of a fresh radio-active substance. The rate at which new offspring of radium, thorium and allied elements are discovered and studied during their fleeting existences reminds one of nothing so much as the genealogy of Noah as given in the fifth chapter of Genesis.[5]

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[4] Experimental details, and also comprehensive treatments of the subject as a whole and of special parts, may be found in three books by J. J. Thomson: 'The Discharge of Electricity through Gases' (based on lectures given at Princeton University in October, 1896); 'Conduction of Electricity through Gases' (a larger book); 'Electricity and Matter' (lectures delivered at Yale University in 1903).

[5] It is an indication of the widespread interest in this subject, and of the activity of the workers in this field, that one journal, in the year 1905, contained no less than 167 abstracts of articles upon radioactive phenomena. E. Rutherford's book, 'Radio-activity,' 2d edition, 1905, is a masterly survey of the whole subject.

These products appear to be elements, and this idea that some elements may have existences of but short duration, from a few seconds to many years, is a decidedly novel one. It has been suggested that this may account for some of the vacant spaces in our periodic table of the elements, particularly in the neighborhood of thorium, radium and uranium. Perhaps these spaces never will be occupied except by transients. Indeed it is not impossible that all our elements are mere transients, mere conditions of things, all undergoing change. But there is no immediate danger of their all vanishing away in the form of rays and emanations. Rutherford has calculated that radium will be half transformed in about 1,300 years, that uranium will be half transformed in 6×10^8 years, and thorium in about 2.4×10^9 years. We may safely say the other elements are decaying much more slowly, so we may continue to direct our anxieties towards the probable duration of our coal beds and deposits of iron ore as matters of more present concern.

The objection may be raised that perhaps radium should not be classed as an element, but rather should be considered as an unstable compound in the act of breaking down into its elements. But the answer to this objection is at hand. The evolution of energy accompanying these changes is far in excess of that obtainable from any known chemical process, so far in excess that it is certain we are dealing with a source of energy hitherto unknown to us, with a wholly new class of phenomena. The following quotation from Whetham[6] will convey an adequate conception of the magnitude of the forces at work here:

> **It is possible to determine the mass and the velocity of the projected particles, and, therefore, to calculate their kinetic energy. From the principles of the molecular theory, we know that the number of atoms in a gram of a solid material is about 10^{20}. Four or five successive stages in the disintegration of radium have been recognized, and, on the assumption that each of these involves the emission of only one particle, the total energy of radiation which one gram of radium could furnish if entirely disintegrated seems to be enough to raise the temperature of 10^5 grams, or about 100 tons, of water through one degree centigrade. This is an underestimate; it is possible that it should be increased ten or a hundred times. As a mean value, we may say that, in mechanical units, the energy available for radiation in one ounce of radium is sufficient to raise a weight of something like ten thousand tons one mile high.**

Again,

> **the energy liberated by a given amount of radioactive change . . . is at least 500,000 times, and may be 10,000,000 times, greater than that involved in the most energetic chemical action known.**

The theory that the source of most of the sun's energy is a decay of elements analogous to radium, to disintegration of atoms, is acknowledged to account better than any previous theory for the great quantity

[6] 'The Recent Development of Physical Science,' W. C. D. Whetham.

of this energy which we observe, and for the length of time during which it must have been given off according to the evidences of geology.

There is no chemical reaction which is not hastened or retarded by a change in temperature. In general, the velocity of a chemical reaction is increased by an elevation of the temperature and diminished by a reduction of the temperature. But radium compounds emit their rays undisturbed, at an even, unaltered rate, whether they be heated to a high temperature or cooled by immersion in liquid hydrogen and, what is perhaps equally striking, whether they are in the solid state or dissolved in some solvent.

In view of such facts as these, it is idle to suppose that radium is an unstable compound decomposing into its elements, using the terms compound and element in their usual sense. Conflict as it may with preconceived opinions, we seem forced to concede, not only that the transmutation of the elements is possible, but also that these transmutations are going on under our very eyes.

As has already been pointed out, this does not mean that we shall shortly be able to convert our elements into each other. Far from it, up to the present time we have not the slightest idea how to initiate such a process nor how to stop it. We can not, by any means known to us, even alter the rate at which it proceeds.

Now how shall we fit all these new facts and ideas in with our old ones regarding the elements and atoms, and how many of the old ideas must be discarded? Brief consideration is enough to convince us that very few of the old ideas, in fact none of value, need be sacrificed. We must indeed grant that Dalton's fundamental assumption is false, that the atom, in spite of its name, is divisible, and consequently that our elements are not our simplest substances, but decidedly complicated complexes. But all the facts included in the laws of definite and multiple proportions remain fixed and reliable, as indeed must all facts, expressions of actual experimental results, no matter what else varies. And there is not the least necessity for altering the methods of using atomic weights in calculations, nor for ceasing to use structural diagrams and models for molecules. We must merely modify our ideas and definition of an atom, and this modification is in the direction of an advance. We know more about an atom, or think we do.

Assume the inferences from the evidence just reviewed to be correct, and how do they affect our conception of the atom? First of all, our smallest, lightest, simplest atom, that of hydrogen, becomes an aggregation of about eight hundred smaller particles or corpuscles, and the atoms of other elements become aggregations of as many corpuscles as are obtained by multiplying the atomic weight of the element by eight hundred. Thus the atom of mercury must be thought of as containing 800 times 200, or 160,000, corpuscles. Next, the methods by which we believe we can calculate the approximate size of atoms and corpuscles

give us values which enable us to make such comparisons as the following, suggested by Sir Oliver Lodge: 'The corpuscle is so small as compared to the atom that it, within the atom, may be likened to a mouse in a cathedral,' or 'the corpuscle is to the whole atom as the earth and other planets are to the whole solar system.'

These corpuscles are probably gyrating about each other, or about some common center, with velocities approaching that of light. It seems needful to suppose this, for it is hard to imagine that the enormous velocities observed could be imparted to a corpuscle at the instant it leaves the atom to become a constituent of a cathode ray. It is more reasonable to imagine that the corpuscle already had this velocity and that it flew off at a tangent owing to some influence we do not understand.

This may appear, after all, to be little more than pushing back our questions one stage, so that the position occupied in our thoughts but yesterday by the atom is now occupied by the corpuscle. Quite true, but this is in itself a great step, for the advancement of knowledge consists of nothing else than such pushing back of the boundaries. We dare not assume the end is reached, for there is no proof that the corpuscles are ultimate. They mark the present limit of our imaginings based on experiment, but no one can say but what the next century may possibly witness the shattering of the corpuscles into as many parts as it now appears to take to make an atom.

The question is a legitimate one, do we know any more about these 'new-fangled' corpuscles than we did about the old atoms? The answer is, yes, we probably do. We can go further in our reasoning on the basis of the properties of the corpuscles, and arrive at results which are startling when heard for the first time.

Lenard[7] has shown that the absorption of cathode rays by different substances is simply proportional to the specific gravity of those substances and independent of their chemical properties. It is even independent of the condition of aggregation, *i. e.*, whether the absorbing substance be investigated as a gas, as a liquid or as a solid. This is another strong argument in favor of the view that there is but one 'mother substance' which consists of corpuscles. The corpuscles of the cathode rays must be considered as passing unimpeded through the interstices between the corpuscles of the atom. Lenard calls the corpuscles dynamides and considers them as fields of electrical force with impenetrable central bodies which then constitute actual matter. He calculates the diameter of this center of actual matter as smaller than $0.3 \times 10^{-10} (= 0.000,000,000,03)$ millimeter. Applying these results to the case of the metal platinum, one of the most dense of the metals, one of those with the highest specific gravity, he concludes that a solid

[7] *Wied. Annal.*, 56, p. 255 (1895), and *Drudes Annal.*, 12, 714 (1903).

cubic meter of platinum is in truth an empty space, with the exception of, at the outside, one cubic millimeter occupied by the actual matter of the dynamides.

If we can thus reasonably and mathematically eliminate the matter of a cubic meter of one of our densest metals to such an extent, it should not be very difficult to make one more effort and eliminate that insignificant little cubic millimeter still remaining, and say, with cogent reasons behind us for the statement, that there is no matter at all, but simply energy in motion. This is exactly what has been done by many who occupy high and authoritative positions in the scientific world.

Long before experimental evidence of the existence of corpuscles had been obtained, it was demonstrated that an electrically charged body, moving with high velocity, had an apparent mass greater than its true mass, because of the electrical charge. The faster it moved the greater became its apparent mass or, what comes to the same thing, assuming the electrical charge to remain unaltered, the greater the velocity the less the mass of the body carrying the charge needed to be to have always the same apparent mass. It was calculated that when the velocity equaled that of light, it was not necessary to assume that the body carrying the charge had any mass at all! In other words, the bit of electric charge moving with the velocity of light would have weight and all the properties of mass.

This might be looked upon as an interesting mathematical abstraction, but without any practical application, if it were not for the fact that Kaufmann[8] determined the apparent masses of corpuscles shot out from a radium preparation at different velocities, and compared them with the masses calculated on the basis that the whole of the mass was due to the electric charge. The agreement between the observed and calculated values is so close that it leads Thomson to say: "These results support the view that the *whole* mass of these electrified particles arises from their charge."[9]

Then the corpuscles are to be looked upon as nothing but bits of electric charge, not attached to matter at all, just bits of electric charge, nothing more nor less. It is this view which has led to the introduction of the term electron, first proposed by Stoney, to indicate in the name itself the immaterial nature of these ultimates of our present knowledge. We have but to concede the logical sequence of this reasoning, all based on experimental evidence, and the last stronghold of the materialists is carried, and we have a universe of energy in which matter has no necessary part.

If we accept the electron theory, our atoms are to be considered

[8] *Phys. Zeitschr.*, 1902, p. 54.

[9] 'Electricity and Matter,' p. 48.

as consisting of bits of electric charge in rapid motion, owing their special properties to the number of such bits within them, and also, no doubt, to the particular orbits described by the electrons. If space permitted it would be interesting to show how admirably the periodicity of the properties of the elements, as expressed in Mendelejeff's table, can be accounted for on the basis of an increasing number of like electrons constituting the atoms of the successive elements. We have molecules consisting, at the simplest, of two such systems within the sphere of each other's attraction, perhaps something as we have double stars in the heavens.

A possible explanation of the puzzling property of valence is offered, in that an atom less one electron, or plus one electron, may be considered as electrically charged, and therefore capable of attracting other bodies, oppositely charged, to form electrically neutral systems. An atom less two electrons, or with two electrons in excess, would have twice the ability to combine, it would be what we call divalent, and so on. An electronic structure of the atom furnishes a basis from which a plausible explanation of the refraction, polarization and rotation of the plane of polarized light may be logically derived. Hitherto explanations for the observed facts have been either wanting or more or less unsatisfactory. For instance, grant the actual existence of tetrahedral carbon atoms, with different groups asymmetrically arranged at the apices, and yet we can not see any good and valid reason *why* such a structure should be able to rotate the plane of polarized light. Grant that the molecule consists of systems of corpuscles traveling in well-defined orbits, and we see at once how light, consisting of other electrons of the same kind, traversing this maze, *must* be influenced.

Adopting this theory of corpuscles or electrons, not a concept of any value need be abandoned. On the contrary, the theory furnishes us with plausible explanations of many facts previously unexplained. Its influence is all in a forward direction towards a simplification and unification of our knowledge of nature.

A few words must be said regarding the old, the threadbare, argument which, of course, is cited against the electron theory. The materialist says he simply can not accept a theory which obliges him to give up the idea of the existence of matter; he says the table is there because he can see it and feel it and that must end the discussion for any one with common sense and moderately good judgment. Now it is the reverse of common sense to let that end the discussion, and our materialist is pluming himself on precisely those qualities which he most conspicuously lacks. He assumes the obnoxious theory to involve consequences which it does not involve and then condemns it because of those consequences. As a rule it is because he knows little about it, and has thought less, that he assumes the electron theory to be pure idealism in an ingenious disguise, that form of idealism which asserts

that there is no universe outside ourselves and that everything is a figment of the imagination of the observer. The electron theory postulates a universe of energy outside ourselves. It does not deny the existence of the table; quite the reverse, it asserts it and then offers a detailed description of it, and why it has the properties which it has. This is more than any materialistic theory can do. The electron theory affirms the existence of what we ordinarily call matter. It defines, describes, explains these things, ordinarily called matter, in a clear and logical manner, on the basis of experimental evidence, as a *mode of motion*. It opposes the use of the word matter, solely because that word has come to stand, not only for the object, but also for the assumption that there is something there which is not energy.

Another groundless objection is offered by the materialists. They say this electron theory is clever, perhaps plausible, but very vague and hopelessly theoretical. Of course it is theoretical, but it is a theory more intimately connected with experimental facts than any other theory regarding the ultimate constituents. One departs further from known facts in assuming the existence of a something to be called matter. What is this matter which so many insist that we must assume? No one can define it otherwise than in terms of energy. But forms of energy are not matter as the materialist understands the word. Starting with any object and removing one by one its properties, indubitably forms of energy, we are finally left with a blank, a sort of a hole in creation, which the imagination is totally unable to fill in. The last resort is the time-honored definition, 'matter is the carrier of energy,' but it is impossible to describe it. The assumption that matter exists is made then because there must be a carrier of energy. But why must there be a carrier of energy? This is an assertion, pure and simple, with no experimental backing. Before we have a right to make it we should obtain some matter 'strictly pure' and free from any energy, or, at least, we should be able to demonstrate on some object what part of it is the energy and what part the matter, the carrier of the energy. We have not done this, we have never demonstrated anything but forms of energy, and so we have no evidence that there is any such thing as matter. To say that it exists is theorizing without experimental evidence as a basis. The materialistic theory postulates energy and also matter, both theoretical if you will; the electron theory postulates energy only. Therefore the electron theory is the less theoretical and the less vague of the two.

From the philosophical standpoint, having deprived an object of all that we know about it, all forms of energy, there remains what may be called the 'residuum of the unknown.' We are not justified in saying that nothing remains; we can only say nothing remains which affects, either directly or indirectly, any of our senses through which we become cognizant of the external universe. If the materialist

takes the stand that this unknown residuum is what he calls matter, although any other name would be equally appropriate, it must be acknowledged that his position is at present impregnable, and that sort of matter exists. But it is nothing with which experimental science can deal. A fair statement would appear to be: The electron theory accounts for, or may be made to account for, all known facts. Besides these there is a vast unknown within whose precincts matter may or may not exist.

Michael Faraday is acknowledged to have been one of the ablest of experimenters and clearest of thinkers. His predominant characteristic may be said to be the caution which he used in expressing views reaching beyond the domain of experimental facts. His authority rightly carries great weight, and it is therefore of particular significance that he expressed himself more definitely upon these questions than appears to be generally known. In an article published in 1844[10] he says:

> If we must assume at all, as indeed in a branch of knowledge like the present we can hardly help it, then the safest course appears to be to assume as little as possible, and in that respect the atoms of Boscovich appear to me to have a great advantage over the more usual notion. His atoms, if I understand aright, are mere centers of forces or powers, not particles of matter, in which the powers themselves reside. If, in the ordinary view of atoms, we call the particle of matter away from the powers *a*, and the system of powers or forces in and around it *m*, then in Boscovich's theory *a* disappears, or is a mere mathematical point, whilst in the usual notion it is a little unchangeable, impenetrable piece of matter, and *m* is an atmosphere of force grouped around it. . . . To my mind, therefore, the *a* or nucleus vanishes, and the substance consists of the powers or *m*; and indeed what notion can we form of the nucleus independent of its powers? All our perception and knowledge of the atom, and even our fancy, is limited to ideas of its powers: what thought remains on which to hang the imagination of an *a* independent of the acknowledged forces? A mind just entering on the subject may consider it difficult to think of the powers of matter independent of a separate something to be called *the matter*, but it is certainly far more difficult, and indeed impossible, to think of or imagine that *matter* independent of the powers. Now the powers we know and recognize in every phenomenon of the creation, the abstract matter in none; why then assume the existence of that of which we are ignorant, which we can not conceive, and for which there is no philosophical necessity?

There is a striking analogy between the present condition of our science and our discussions, and those prevailing in the latter half of the eighteenth century when the phlogiston theory was almost universally accepted. We all now believe that heat is a mode of motion and smile at the thought that there were those who considered heat as a material. The materialistic theory is the phlogiston theory of our day, and perhaps the time is not far distant when the same indulgent smile will be provoked by the thought that there were those unwilling to believe that matter is a mode of motion.

[10] 'Experimental Researches in Electricity,' Michael Faraday, Vol. 2, pp. 289–91.

PURE FOOD LEGISLATION

By ROBERT McD. ALLEN,

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THE facts and evils of food adulteration have been overwhelmingly established. They have been published in volume after volume of state and federal government reports, and have been sworn to again and again by competent experts. State courts have imposed fines, and in hundreds of instances manufacturers and dealers have confessed that their food is adulterated, and judgments are entered accordingly. Yet, the evil is so strongly entrenched in business systems that a proposition to put truthful labels on foods and drugs intended for interstate commerce has met continuous defeat for more than fifteen years at the national capital.

Most of the states have enacted laws to control the manufacture and sale of foods. Some of these laws are good. Others contain bad provisions in an otherwise good law, provisions intended to nullify the law as it may apply to the several practises which food legislation is needed to correct, and such provisions but serve to legalize some adulteration which would have been subject to prosecution at common law. The main principles of the state laws have been well established by the Appellate Courts of the states and by the United States Supreme Court in a long train of decisions. With this backing, some eight or nine of the states are thoroughly enforcing their laws, and, as a result, there is a marked betterment in the food supply coming into such states.

The State Food Control Officials have an organization known as the Interstate Pure Food Commission. The commission was organized in 1896 for the purpose of bringing about uniformity among the state laws and securing the passage by congress of a law to apply to interstate commerce. This commission has held annual meetings, and at each meeting resolutions were adopted setting forth urgent reasons for national legislation to supplement the state laws. In nineteen hundred and three at Saint Paul, Minnesota, the commission called a joint meetings of manufacturing interests, state officials and representatives from the Bureau of Chemistry and the Inspection Division of the Bureau of Animal Industry of the United States Department of Agriculture. The manufacturers were given the full privilege of the floor, the discussions were frank, and, as a result of the meeting, the officials were impressed with the fact that in the preservation of the large fruit and vegetable crops much of food adulteration comes

from problems which the manufacturing interests are honestly endeavoring to overcome. As a further result of this meeting, it was impressed upon all that food-control legislation should be correct labeling rather than prohibitive, except where substances are positively injurious to health.

The Saint Paul meeting was followed by a similar and larger meeting at the Louisiana Purchase Exposition in the nature of an International Pure Food Congress, and an exhibit showing adulterated brands of foods. The Saint Louis meeting was the largest of its kind ever assembled, and was a week, day and evening, of frank, honest discussion among officials, scientists and representatives from the several manufacturing interests. The congress discussed antiseptics, artificial colors, fruit, vegetable, dairy and meat products, confectionery, baking powders, wines, beers, distilled liquors and drugs. Special committees reported resolutions on the various questions, and among the resolutions adopted was a unanimous endorsement of the Hepburn Pure Food Bill which had passed the United States House of Representatives the previous winter.

For more than twenty years the Bureau of Chemistry of the United States Department of Agriculture has thrown the weight of its influence to the investigation of food and drug adulteration and its effect upon health. This bureau has had the cooperation of the association of Official Agricultural Chemists in perfecting methods of food analyses and in collaborating on a set of food standards. It is the agricultural chemist who has detected and called the country's attention to the evils of food adulteration. Formerly laws regulating the sale of foods were left to the boards of health to be enforced, but it is only as the states have created divisions of chemistry in the Department of Health, or have turned the work over to their experiment stations, or have organized state food commissions and equipped them with laboratories, that results have been obtained under state laws.

Food and drug adulteration has grown up because interests have been permitted to violate certain principles of identification in the sale of their products. When purchasers know *where* a product was made, *when* it was made and *who* made it, and are informed of the *true nature* and *substance* of the article offered for consumption, it is almost impossible to impose upon the most ignorant and careless consumers. Trade-mark law requires correct labeling as to *who* made an article and establishes the principle that a man is not to sell his goods under the pretense that they are the goods of another man, nor can he use any means which will contribute to this end. This principle has been upheld in courts as not only necessary to secure to each man the fruits of his own toil, but also as a protection to the public against fraud. Only the one, however, whose trade-mark is infringed has a cause of action before the courts, and where there is a business

arrangement, or where monopoly operates, to put the combined product of many factories into the market under that trade-mark which is most in favor with consumers the public have no remedy at trade-mark law. The large wholesalers oppose the proposition to have the label tell, under all circumstances, the name of the real manufacturer. The independent manufacturing firms strongly favor it. There is nothing so fatal to monopoly or so stimulating to the competition of individual merit as where law requires an article of merchandise to be always identified in the market with the name of the person or firm who made it.

Congress has passed several laws relating to inspection and correct labeling. In 1890, a law was passed authorizing the inspection of meats intended for export, and forbidding the importation of adulterated foods and drugs. In 1891, the meat inspection provided for in the act was extended to meats intended for interstate shipment. The provisions of this law were further extended in the Appropriation Act of the United States Department of Agriculture for 1905 to apply to daily products intended for export. In 1896 congress provided for the bottling of genuine whiskey in bond and its identification to the consumer by means of a tax stamp over the cork. In 1897 a law was passed prohibiting the importation of inferior teas, and providing for a board of experts to adopt standards by which to measure the quality of imported teas. The law and the provision authorizing this board of standards have been held to be constitutional by the United States Supreme Court. During the war with Spain a special tax was levied upon certain products, among them adulterated flour. The tax stamp served to identify the flour subject to this tax, and the business was at once destroyed. In repealing the war taxes the act relating to adulterated flour was not repealed.

In 1896 Congress passed an act providing for the taxing and labeling of filled cheese. Oleomargarine was a subject of federal legislation as early as 1885. This act was passed as a tax measure, and in connection therewith provided for the proper labeling of oleomargarine. This law was amended in 1902, fixing the tax on oleomargarine, colored to resemble butter, at ten cents per pound, and on the uncolored at one fourth of one cent per pound. It also taxes renovated butter, and requires it to be so branded.

The Appropriation Act of the United States Department of Agriculture for 1903 and subsequent appropriation acts have authorized the Secretary of Agriculture to put into effect the act of 1890 relating to the importation of adulterated foods and drugs, and to adopt and fix standards for guidance in the enforcement of the law. Appropriation acts of the Department of Agriculture have also authorized the study of the effect of antiseptics and artificial colors on the human system. It was under these acts that the chief of the Bureau of

Chemistry, assisted by details from the medical staff of the army, experimented with the 'poison squad,' and as a result has recommended against the use of salicylic, benzoic and boric acids to preserve foods.

Congress passed a good law in 1902 prohibiting the misbranding of foods as to the state or territory in which the product is produced. This law was passed primarily to keep western cheese producers from labeling their product as 'New York' cream cheese. The law applies, however, to all foods, and it puts into partial practise one of the important principles of identification, namely, *where* a product is made. Where a product is made is an important bit of knowledge. Foods sometimes have exceptional qualities by reason of certain conditions of climate and soil and skill in packing or preserving. And so it is that certain fruit, vegetable, dairy and wine districts are known for the superiority of their products. The producers in these districts have the right to an honest market, while consumers should have the means to identify the foods from such districts should they so desire.

Correct labeling as to the geographical place of production prevents imposition in another way. A man can pack cottonseed oil for interstate commerce and label it 'olive oil,' but if he is compelled to state that the 'olive oil' is packed in Georgia or Alabama, the public becomes suspicious that it is getting cottonseed oil. A 'New Orleans' molasses, packed in one of the glucose districts of Illinois, is open to the same suspicion. A can of 'salmon,' packed in Minnesota, is known by its place of production to be carp. Between products of the same class this law is effective; but between the imitation and the product imitated, it is of little avail, for raw materials can be shipped into a district famous for its cheese, jelly, syrup, wine or whiskey, and the label of the imitation then bears legally the name of that district which is in favor with consumers.

Federal legislation is incomplete. The Hepburn-McCumber-Heyburn Pure Food Bill proposes to complete it. Not by a tax, but by a law which will command all the principles of identification to be truthfully and fully represented before foods, drugs and liquors are allowed shipment from one state into another. Such a law will make it possible to follow fraud across the state border and to punish the person responsible for the manufacture of an adulterated or misbranded product. Such a law will tend to unify state laws, but it will not interfere with state laws nor will it protect that state which does not maintain equal inspection over its own commerce.

The attitude of the food interests toward pure food legislation is either passive or antagonistic. The meat packers represent to consumers that their meat is 'U. S. government inspected.' The act of 1890, which relates to physiological wholesomeness only, permits them to make this representation, although meats, 'U. S. government inspected,' may contain antiseptics, aniline dyes, cheap fillers and any

other adulteration or misbranding which the packer may find profitable after the carcass has passed veterinary inspection. The packers are considered to be opposed to a law which will prohibit or make public these added adulterations. The butter people have secured all the special legislation they desire and of course take little interest in a general food law. In fact a general food law may in the end restrict the use of artificial color in butter.

The brewers support the bill. This is brought about by the influence of strict regulations in Germany. The wine growers favor the bill on account of the advantage which the port inspection gives foreign wines over the uninspected American wines. Wines, however, are largely distributed through the wholesale liquor dealers. The majority of wholesale liquor dealers are also rectifiers. The rectifier, either through lack of confidence in his product, or some misunderstanding regarding the purpose of the bill, is its strongest opponent. The wines of any firm openly supporting the bill are therefore liable to be discriminated against.

Some manufacturers of catsups and other condiments fear that the law will prohibit the use of antiseptics. Others announce that such articles can be put up without these preservatives. The manufacturers of imitation jams and jellies supported the law at first, believing that it would bring about a uniform system of labeling. The enforcement of the labeling provision under the state laws, however, is now proving that consumers prefer the genuine product. The independent firms which put up pure foods of all kinds are for the bill; but such firms are not organized, maintain no lobby, and with several aggressive exceptions write few letters to congressmen and do little of anything else to offset the influence which the organized interests array in opposition. The reasons for using antiseptics, artificial colors and flavors and otherwise adulterating foods may be controverted, but no one will deny the right of consumers to know it whenever such adulterations have been practised. Manufacturing firms realize this and they are preparing to meet what they know consumers will demand when law compels such labeling. The head of a large association of food interests well expressed this in saying: "I have lost sleep for several years trying to see some way around the movement, but there is only one thing to do and that is to prepare to meet it." The majority of the food interests are preparing. Firms which began several years ago to so shape their business are ready. Others will be ready, but they would like to see such laws postponed for one or two more years. When the expense of making the change is incurred and the pure food policy has been inaugurated, business itself will demand the enactment of strict inspection laws.

All practical reform must be financed. Pure food is a sentiment until put into practise in the dairy or factory. The practise does not

continue without profit. The profit is uncertain, often impossible, until the laws of the state and of the nation command that every article of commerce shall be sold under its own name and upon its individual merits.

In the enforcement of the state laws, in the committee hearings concerning the proposed national law, the dominant questions have been, and, in the event of the passage of the national law, will be, artificial colors, antiseptics, standards and labeling. And at the present time the adulteration and misbranding of drugs and liquors occupy a prominent place in the pure food issue.

Artificial Colors

In a pinch of aniline dye there is all of the color which a cherry-tree can produce in one season. The cherry juice or the cherry jelly is refreshing and invigorating, while the aniline dye, whether harmful or harmless, is without food value, lifeless and dead.

Genuine color and flavor are the truest representations of quality and purity, and the artificial color or flavor is *per se* a deception. Even in confections when the product purports to be flavored with lemon, vanilla, cinnamon, etc., and is not, the artificial color or flavor works a fraud. With the aid of color every article of food has been in appearance successfully imitated. With artificial color to depend upon, there is little need for selecting the best suited feeds and treating and culturing cream in such a manner as to produce a delicious butter with sufficient natural color. Little attention need be paid to the growing of fruit and vegetables uniform in color and quality, or to the treatment of the wholesale lot so that it will be uniform when it leaves the process of preservation, since no care in production or preservation can produce a color which can compete with that added by the aniline dye.

The manufacturers claim, and it can not be disputed, that the use of a harmless color to restore the appearance of a product of otherwise good qualities is not concealing inferiority, but makes the material, which is standard in all other qualities, pleasing to the eye. But where can the line be drawn? Once throw the gate open and the imitator enters with his saccharin and glucose, starch and waste products from the fruit factories and artificial acids to color compounds for the market which are often worthless and sometimes harmful.

Color should no longer be a subject of class discrimination. The dairy interests defend its use to improve the quality of cheese and butter; the packers, to change the appearance of their oleomargarine; the vinegar factories to help them make cider vinegar without apples; the French, to protect their industry in coppered peas; and all the imitators as their *modus operandi* in deceiving the public. In each and every instance it either deceives as to the quality of the product or aids in the sale of that which has no value, or assists the sale of

some product under the name of another, at, perhaps, double its market price.

Antiseptics

Antiseptic preservatives are substances to be restricted, if possible, prohibited. This is the conclusion reached in all legislation, in the reports of scientific commissions appointed by governments to inquire into the use of antiseptics in foods, and by the large majority of experts who have studied the effect of the long-continued use of minimum quantities upon the human system.

Those who employ antiseptics to aid in the preservation of foods do not defend this use because of *wholesomeness,* but because of *conditions*—honest problems—in the production and sale of soda fountain syrups, tomato catsup and similar articles put up ready to serve, and which remain open for a week or longer until the contents of the package are consumed. And in this defense the reasons come more from the *market*—'rough handling in shipping,' 'the hot grocery shelf,' and 'the careless consumer'—than from problems in *production.*

The antiseptic is the competitive foe of cleanliness and other hygienic practises which should attend throughout the production and sale of foods. The antiseptic is often used in foods of otherwise high standards, but it is more often found substituted for wholesome practises or ingredients. Its use discourages the perfection of healthful ways for keeping foods—chilling, sterilizing, ripening, curing and the combination of one food substance with another—which have not only given us food preservation, but have added delicious and wholesome variety to what we live on.

Some of the state laws specifically prohibit the use of antiseptics in foods. Other laws prohibit the addition of 'injurious substances' to food products, and in the enforcement of such provisions, as in Pennsylvania, for example, the court holds that such a provision applies to the use of a harmful antiseptic even in a minimum quantity. In Connecticut and Kentucky, while the law prohibits the addition of 'injurious substances' to foods, it also requires the use of any antiseptic to be made known to the purchaser or consumer. Under the enforcement of this labeling provision Kentucky, for example, has meats without boracic acid, milk without formaldehyde, jellies and fruit juices without salicylic acid, while some of the manufacturing firms are successfully putting up tomato catsup and soda fountain syrup without the use of benzoic acid or other antiseptic preservatives.

In a letter to the Kentucky department a manufacturer of tomato soup writes:

> During the season of 1905 and henceforward the use of coal-tar dye and benzoate of soda will be entirely discontinued from our product, for we have arranged to make it entirely from fresh tomatoes in the height of the packing

season which will enable us to produce a palatable looking article without the color, and relieves us from the necessity of putting away stock and preserving it with benzoate of soda to avoid fermentation.

In a letter from one of the meat packers it is brought out that one manufacturer is required to use boracic acid to maintain a competitive keeping quality with the other manufacturers, if there is no law or enforcement of law to prevent or make public the use of antiseptics in meats.

Writing of the experiment with tomato catsup without an antiseptic, the manufacturing head of one of the large firms says:

I believe that within five years, if that long, we could create ideal conditions in this country, and the consumer could be educated to take better care of such goods as are perishable and liable to spoil on his hands if not consumed within a certain time. Smaller packages would help to a large extent in that direction. In fact, there are numerous ways by which eventually we may accomplish that which is desirable to be done.

The head of the market end of the firm, writing about the experiment later says:

We are making a strenuous effort to have every variety of our goods absolutely pure and free from any antiseptic whatever. But you appreciate thoroughly the enormous undertaking this is, and, further, the great interest which we have at stake which makes us proceed slowly. Starting several years ago with our experiments on tomato catsup, we put out at first five or six thousand dozen; the next year we doubled that; the next year we doubled that again; this year we are going to put out approximately four hundred thousand dozen catsup, which will be absolutely free from any coloring matter or antiseptic. With this season's work a success, we will have demonstrated beyond any possibility of doubt the putting up of catsup without any antiseptic. After that you will be free to say to every manufacturer who sells otherwise, 'Look at the thousands of dozens of catsup that . . . has on the market which stand the test of shipping, of climate, and, afterwards, the hot shelf of the grocery store, and still the consumer gets the goods in prime condition and is well satisfied with the flavor.'

Tomato catsup has been claimed to be the most difficult product to put out without some antiseptic.

Added or Otherwise

The provisions of the food laws and of the proposed National Pure Food Law apply principally to adulteration by *addition* and to adulteration by *taking away*. There is a third class of adulteration. Foods may be unfit for consumption by reason of inferior methods of production or preparation, carelessness in handling, inherent disease, and the spoilage to which foods are subject by their very nature. Many foods at certain stages of production or preparation are unfit for consumption—a green peach and new whiskey. Many of the fruits and fruit or grain products contain in their composition certain normal poisons, poisons which a food law would prohibit being added. It is

said that in some instances these poisons are not active in the combinations in which nature puts them, but whether active or not active when people eat a natural product they know the nature of that which they eat, and when a food law requires this product to be put up in its best form and to be identified to the consumer, it has gone as far as is necessary.

The opponents of the Hepburn-McCumber-Heyburn Pure Food Bill argue that it is unfair, because it prohibits the addition of poisonous ingredients, and yet permits a poisonous ingredient when inherent or normal in the product. This argument is plainly invented to divert attention from the question of honest labeling. It seems at first plausible; but its fallacy and purpose are evident upon short analysis. The proposed law prohibits directly the sale of animal or vegetable substances which are diseased, spoiled, or otherwise unfit for food, and the majority of the other provisions of the bill apply indirectly to adulterations present without having been added. Adulteration by inferior methods of production or preparation necessitate the artificial colors and flavors, antiseptics and other added substances which the bill proposes to regulate. Imperfect natural food bears its own condemnation in its unpalatable flavor and inferior color, and such a food, therefore, must be supplemented and disguised by the added artificial before it will sell. When the artificial is added the law operates. Foods which possess a natural color and flavor pleasing to consumers are the result of the highest arts of production and preparation, and it is not for such foods that food control legislation is needed.

The whiskey rectifier or blender in particular has attacked the word 'added' in the following provision:

> **If the package containing it (the article of food) or its label shall bear any statement, design or device regarding the ingredients or the substance contained therein, which statement, design or device shall be false or misleading in any particular, provided, that an article of food which does not contain any *added* poisonous or deleterious ingredient shall not be deemed to be adulterated or misbranded in the following cases.**

No open argument can be put forward against the first part of this provision, but from the overwhelming evidence of such misbranding, not only in the sale of liquors but in the sale of all foods, it is evident that there must be a powerful secret opposition to it. This opposition manifests itself in charges of 'government bureaucracy,' 'the tyranny of standards,' 'differences of opinion between scientists,' 'the competency of the agricultural chemist *versus* the competency of the physiological chemist in determining adulterations,' 'added or otherwise,' 'the constitution,' 'the enforcement of law by an individual instead of by the courts,' as if it were possible under the state and federal constitutions to enforce any law in case of dispute by other than the courts.

Application of the Law to Whiskies

The pure food issue covers, and should cover, all substances intended for human consumption, and the fact that any subject covered in the issue is difficult and unpleasant is the more reason why it should be included.

Whiskey is ethyl alcohol and natural flavor. Brandy is ethyl alcohol and natural flavor. The difference is the difference in flavor. The flavor of genuine whiskey comes from the grain, secondary products—fusel oil—distilled over with the ethyl alcohol and ripened into the flavors of 'rye' and 'Bourbon' whiskey. The new whiskey with its unripened secondary products is like the green peach, unfit for consumption. The quality of the flavor of whiskey depends upon the quality of fusel oil and the method and period of aging. The quality of the fusel oil depends upon the quality of the grain and water used, the preparation of the mash and the methods of heating and distilling. The new product is ripened by putting into charred oak barrels and storing these barrels in warehouses. These warehouses are under the lock of government officials, primarily to see that none of the product is taken away until the tax is paid. Whiskies may be taken out of this warehouse at once, or they may be permitted to remain for a period of eight years before the government collects the tax and ceases its control. Most of the whiskey, however, is tax-paid and removed from bond before it is three years old. The rectifier or blender claims that he has a process for producing palatable whiskey without the expense and delay of the barrel-aging process. The rectifier, however, colors, beads and labels his product in imitation of the aged whiskey. If the process has the merit which is claimed for it, there should be no injustice and all advantage in a law requiring rectified whiskey to be labeled for what it is.

When the tax is paid on distilled spirits the government puts a stamp on the product to show this fact. Formerly these stamps were only put on barrels. Consumers do not buy the product by the barrel, and so in 1896, following the investigation of the whiskey trust and the adulteration of whiskies, congress passed an act permitting a tax-paid certificate stamp to be put over the corks of bottles. Whiskey to be so bottled must have remained in the bonded warehouse at least four years, and must be bottled without the addition of any substance except distilled water to reduce it to one hundred proof. This law is optional. The four-year period of aging which it requires should be made compulsory for all whiskey.

No such supervision is exercised, on the contrary, over the business or product of rectifying. In fact, the rectifier or blender holds a government license to 'spuriously imitate' as he pleases, and a law is needed to restrain the adulteration which it is possible to practise. The natural flavor in genuine whiskey and the government tax are the

dominant costs in production. The rectifier seeks to lessen these costs by expansion, or by the addition of artificial essences to neutral spirits to make a product which will taste and appear like genuine whiskey. Sometimes more or less genuine whiskey is mixed with this neutral spirit to help the flavor, and when such is the case, and when the flavors and other imitations added are harmless, the product has all the rights of the market provided it is labeled for what it is.

New genuine whiskey is often taken from bond before it is sufficiently aged and syrups are added to make it palatable. Green whiskey is unfit for consumption, and this practise should be prohibited. In one class of rectified whiskey the mixer not only seeks to avoid the cost of producing the natural flavor, but also to reduce the tax cost of the ethyl alcohol by incorporating some one of the non-taxed intoxicants, like wood alcohol. There are no statistics to show to just what extent this practise is carried on. It is such stuff as this which is sold in the 'dives' of cities and the 'blind tigers' of prohibition districts, and its crazing effect upon human beings is a matter of common knowledge.

The people who do not drink alcoholic beverages know little and care less about the composition and labeling of these products. "They are all bad because they contain ethyl alcohol, and there can be little difference between the adulterated and the pure." Some of the prohibitionists even fear that the investigation might help to 'legalize part of the traffic.' But it would seem wiser to insist that the searchlight of chemistry and the law of the honest label shall be applied to all substances intended for human consumption, whether foods, drugs or liquors. And such a control for alcoholic beverages is the beginning of a far-reaching reform. Some things are worthy of the sentiment of state rights. The adulteration of alcoholic beverages is not one of them.

Standards

All agree on the general principles of pure food legislation, but a controversy arises when it is proposed to apply these principles to the sale of some special product. The name and describing terms given to or incorporated in the label of an article of food or drink have much to do with the price and supposed food value of the article so named or labeled. The imitation, where law does not prevent it, goes into the market under the name and trade terms of the product imitated, and is so mingled in the market with the general food that it is impossible for consumers to distinguish between the two.

It is the purpose of standards to determine and establish the normal constituents of each food substance and to so apply and restrict names and describing terms that consumers can at once identify the imitation from the genuine or the inferior from the superior. The interests

which produce the genuine want this principle established; the interests which make the imitation do not.

The purpose of standards embraces the principle of uniform weights and measures. The law of weights and measures determines what shall constitute a pound or a gallon, and requires that when a pound or a gallon is contracted for the substance delivered shall weigh or measure according to the contract. The law of standards would require that a pound of butter and a gallon of honey shall be such, with all the qualities of good butter and good honey. This standard principle is well established at common law, but the statute and commission are necessary to put it into continuous effect. The impression has been created that it is the purpose of food standards to arbitrarily determine what people shall or shall not eat, when, the fact is, the purpose is not to prohibit but to identify. Food standards will prevent the arbitrary imposition upon consumers which dishonest labeling permits.

For protecting consumers and to meet the ends of justice in the enforcement of food laws it is not only needed to know what this man or that man or these two men consider the qualities of a pure product, but also, what the collaborated evidence from all of the scientists and of all practical experience establish these qualities and the correct method for determining them to be. This collaborated result is the standard, and is, from its very nature, a protection against error.

The legal status of scientific commissions appointed by the state and national governments to determine certain facts in order to intelligently enforce laws becomes an important question when the findings of such commissions affect large interests. In the enforcement of police regulations against ignorant offenders, and in matters of undisputed public importance or danger the rulings of executives and the findings of government scientists have been given the warrant of law without dispute. But in settling a question which concerns established business, the authority for the appointment and the powers of the commission to investigate such questions become a matter of great importance. Such a commission exercises, in the consideration and determination of technical matters, the combined functions of the legislative, executive and judiciary up to the point of putting its findings into effect. Its findings may go into effect by the mutual assent of the interests affected, as is, with but few exceptions, the case where the finding is correct. But if disputed, the finding can not go into effect with the warrant of law, except under the rules and as the weight of evidence.

In his great speech on the constitutional right of congress to pass legislation limiting the power of the inferior federal courts to grant injunctions against the decisions of a railroad rate commission, until after full review, Senator Bailey says in defense of giving such a commission of experts the fullest powers possible:

I do not believe that this legislation will lead to the end which some men fear. I believe that the ultimate effect will be to promote a better understanding among the railroads and the people. I believe that when it is made the railroads do the people justice, the people will feel less resentful toward the railroads; and we will deal with these questions with more of reason and less of passion. It will take the railroads out of politics and we will hear no more about railroad senators. I want to see every corporation driven out of politics.[1]

In opposing the pure food bill the senator says:

Thus it is that bureau after bureau is built up and we vest them with such extraordinary power, until the American people will become a bureaucracy instead of a democracy—a government in which the bureaus and not the people rule.

If the federal government has the power to pass an act regulating the use of adulterated, misbranded and imitation foods, it ought to stop when it writes upon the statute books that it will be a crime to commit such a commodity for shipment between the States and the foreign nations, and leave it to the integrity and efficiency of its judicial officers to vindicate the authority of its law.[2]

Why should not the senator's argument in favor of the rate commission also apply to the food commission? Why should not also the liquor corporation, the drug corporation and the packing corporation be 'driven out of politics'? Why should rate experts, with extraordinary powers, be trusted to make 'the railroads do the people justice,' and food experts, with no limitation upon the courts, be expected to build up a bureaucracy antagonistic to the people's interests?

But, aside from these questions and the 'efficiency and integrity' of the judicial officers, the district attorneys and federal judges can not enforce a pure food law without facts and these facts can only be secured through a 'bureau' or staff of trained chemists, working in well-equipped laboratories under methods of analysis which have been established beyond doubt to be correct. There may be some occasion to fear that errors will be made in securing this evidence. There is greater occasion to fear that the investigation will make public the deficiencies and adulterations which some interests know to exist in their misbranded products.

The pure food issue is not altogether an issue of 'fraud' and 'poison,' but it is more largely a question of scientific and business problems—problems attending the preservation, packing and distribution of what the people live on; problems which the colleges and universities have too long left out of their courses, and problems which the experiment stations and government departments have too long neglected to study in connection with the production of the fruits, grains and other products from which foods are made.

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[1] Before U. S. Senate, April 10, 1906, *Congressional Record*, April 13.

[2] Before U. S. Senate, February 21, 1906, *Congressional Record*, February 21.

WOODEN FLOWERS

By ORVILLE PAUL PHILLIPS, Ph D.

BERKELEY, CAL.

OWING to the demand of the uneducated mind for any kind of a crude guess rather than an acknowledgment of ignorance, strange stories often spring up around natural phenomena, attributing, in most absurd ways, effects to causes which have no more connection than the barnacles and geese of Gerarde. Especially is this true of the savage who deifies everything beyond his knowledge and attributes to it influences for good or evil to himself, according to his first impressions of them. Such stories often find credence in the minds of more enlightened people upon the plea that 'the Indian lives so close to nature that he can not be far wrong in his estimate of natural phenomena.' These believers in the infallibility of the 'untutored races' fail to remember that the most superstitious person on earth is he who reads nature, as does the savage, only by the awe-inspiring phenomena that have forced themselves upon his attention most strongly by some accident, without any reference whatever to cause and effect. Cases in point might be cited from every stage in the life of native races, but the following will serve as an example, and at the same time may clear up in the minds of some as to what is the cause of the peculiar growths known as 'wooden roses' or 'wooden flowers,' they having frequently been described to the writer by different botanists as 'fungi,' 'galls,' 'knots,' 'disease swellings,' etc.

Volcanoes have ever been looked upon with fear by native races and the crater shunned as the doorway to the 'infernal regions.' Agua, in Guatemala, had, however, been inactive for so long that when peculiar forms of plant life, known nowhere else in the region, were found near its summit, they were supposed in some way to be connected through the extinct, though still feared crater, with the regions of fire beneath. They were, therefore, called by the euphonious title of 'roses of hell,' because they were believed to be the only flowers that grew in the 'lower world' and, having escaped through the crater from that region, were supposed to exist nowhere in the world except upon the upper portion of the sloping sides of this volcano.

Because of their supposed origin, these 'flowers' were feared as having great power for evil. They were supposed to be more poisonous than anything upon earth, and any person coming within the influence of their inodorous, though not unbeautiful, 'petals' was marked for sure destruction.

Though Agua had been quiescent for centuries and its rampages were known only by the dim recitation of Indian tradition, still that tradition was strong enough in the hearts of the natives to cause them to warn the Spaniards who came to that country in 1524 that unless they shunned the influences of this 'flower' they would surely be slain by the volcano, whose long quiescent throat had permitted the 'roses' to see the light of day as a warning to human beings that, though he slept, he was by no means dead, and if aroused the Indians would suffer as well as the white man. Despite this warning, the Spaniards called their council under the shade of one of the very trees which bore these 'flowers,' and there decided to found the city of Antigua which was to be the capitol of the new state of Guatemala. Everything flourished in the new city until 1541, when Agua suddenly burst forth in terrific defense of his invaded sovereignty, deluging the beautiful valley with fifty million cubic yards of water and mud, completely burying the city from view and warning the people to no longer trespass upon the evil ground. The warning was again unheeded, the city rebuilt upon the old site and apparent prosperity experienced until 1773, when it was shaken to ruins by the great earthquake. The capitol was then removed to the new town of Guatemala, beyond the influences of the fateful 'flower' and has therefore never been molested since. This

FIG. 1. A BRANCH OF *Citrus medica*, showing the cup-like, delicately carved 'petals of the 'wooden flowers.'

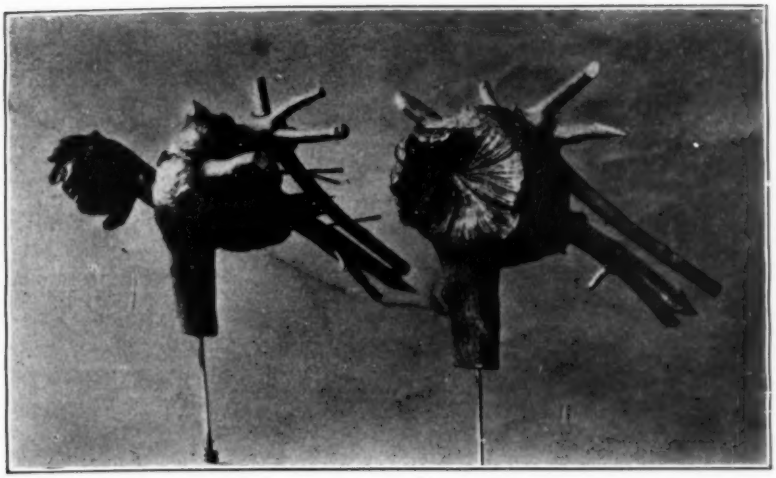


FIG. 2. A BRANCH OF *Citrus medica*, showing the parasitic *Lorenthus Ladebeckii* (Engl.) *in situ*, taken in front of a mirror so as to show both sides of the same specimen. The right-hand view also shows one of the cup-like 'flowers,' from which a plant of *L. Ladebeckii* has fallen. This photograph was kindly made for the writer by Dr. Voigt, of the Botanical Museum of Hamburg.

vindication and fulfilment of the natives' warning has fastened the tradition unalterably upon their beliefs, and no amount of enlightenment ever shakes their confidence in the direful results that will follow the too close inspection of these terrible 'roses of hell.'

This peculiar botanical formation, though strange in its gigantic size, is easily explained when the specimens are carefully examined. An examination of a number of them by the writer showed them to have a 'stem' of wood, upon the end of which was the enlargement or 'flower.' The outer or convex side of the enlargement is covered with a continuation of the bark of the 'stem,' the bark ending at the outer edge of the 'petals.' The concave or inside of the 'flower' is delicately creased like the veins of a petal, running from the center to the periphery, as shown by the photographs. Many of the flowers showed decided indentations in the periphery, as if divided roughly into four-parted 'corollas,' and varying from eighteen to twenty inches in diameter down to minute growths. They might, therefore, easily be mistaken for flowers by those who can not reason from effect back to cause.

The real cause of these peculiar growths is found in the biological law that every organism will protect itself against outside intrusion if it can. Thus when any foreign substance, whether living or inert, enters the living organism, the intrusions are resented by the organism, which tries to protect itself by either assimilating the intruder, ejecting it, or by building up a barrier around it. Thus when the seeds of the parasitic order Lorentheaceæ adhere to the bark of a tree by the gelatinous coating which surrounds them and there germinate, sending

their parasitic roots down through the sap wood of the host to procure their nourishment, the host, not being able to eject them entirely, forms a ball-like excrescence around the juncture of the two plants by the irritable hypertrophy of the tissues thus caused in the host. If the invading plant be pulled out of the growth thus formed, a delicately carved socket will be seen, very much like that of these 'wooden flowers,' but upon a smaller scale. Thus such a 'flower,' though small and usually upon a large limb, is formed whenever a mistletoe grows upon an oak.

FIG. 3. A BRANCH OF *Pirus*, showing the 'wooden flowers' roughly divided into four petals.

These large 'wooden roses' are, therefore, nothing more than the protective hypertrophied tissue formed by the branches of some host tree when attacked by a parasite, which in this case is a gigantic species of mistletoe, *Lorenthus Ladebeckii* (Engl.), growing upon any one of several host trees, the principal ones being *Citrus medica* and several species of conifers. The *Ladebeckii* flourishes in isolated zones throughout the western coast of the American continent from northern Mexico to Terra del Fuego, but has never been authentically reported from any other part of the globe.

The one remarkable thing which attracts attention to these growths and causes them to be mistaken for flowers is the great proportions attained by them. The 'stem,' which of course is a limb of the host plant, rarely exceeds an inch and a half in diameter, the parasite evidently not being able to attack other than the younger and more vigorously growing shoots. As long as these can supply the nourishment for the *Ladebeckii*, it grows, the excrescence upon the citrus becoming larger and larger until the distal portion of the branch dies, leaving the small inner portion of the branch supporting a large ball from which grows the parasite. At the end of a few years, say four to seven, sufficient nourishment can no longer reach the parasite, either because the small supporting branch can no longer carry it, or the protective excrescence has shut it off from the intruder, which therefore drops out, leaving the open, delicately carved formation, which so resembles 'wooden flowers' as to give rise to the remarkable legend above recounted.

THE GEOLOGICAL PRELUDE TO THE SAN FRANCISCO EARTHQUAKE[1]

By GEO. H. ASHLEY
WASHINGTON, D. C.

SINCE the San Francisco earthquake, the reading and scientific public has become acquainted with the fact, if not already known, that the recent disaster was the result, not of volcanic activity, but of the activity of the ordinary mountain-making forces. In a large measure they have become acquainted with the further facts that mountain-making forces have long been, and still are, active in the immediate region about San Francisco; that as a result of these activities the rocks of the regions are folded and faulted; that the faulting is of major importance; that the recent disturbance is ascribed by the geologists to movements of adjustment along one or more of these fault planes; that investigation after the earthquake along some of these lines gave abundant evidence of differential movement visibly affecting the surface.

These facts, now widely known, start questions along several lines of inquiry. One of these lines, having an important bearing on the probabilities of future trouble, involves the geologic evidence as to the recency of the observed earth movements; the relative value of this last displacement as compared with past displacements, both remote and near; the character and amount of geologically recent movements; in short, as given in this paper, a résumé of the recent geologic history of the San Francisco peninsula and the observed evidence upon which the statement of that history is based.

As our interest increases with the recency of the events the earlier history will be passed over rapidly and increasing attention given to the later events.

California in Mesozoic time was the theater of profound geologic activity—the movements of subsidence, the vast volume of sedimentation, the intrusion of great sheets of igneous rocks, and the final folding, crushing and faulting were possibly not exceeded anywhere in the world during that period. In Tertiary time the same notable activity continued. The last expression of that activity in the immediate neighborhood of San Francisco consisted of a subsidence beginning apparently just at or before the end of Miocene time and continuing probably a little over into the Quaternary. Coincident with this subsidence was sedimentation that locally resulted in the laying down of over 4,700 feet of sediments. A remnant of these deposits, known as the Merced series, stretches from the city limits of San

Francisco southward along the coast for 4 miles, beautifully exposed in bare cliffs 700 feet high. A study of the geology shows that this fragment lies between two fault planes, beyond which no trace of it is found for many miles. Calculation shows that on either side of this depressed block there has been elevation during Quaternary time of about 1½ miles with *pari passu* removal of the Merced series and deep erosion of the underlying basement. The time interval is best measured by the erosion of the mile of Merced sediments. As exposed to-day upturned along Seven-mile Beach, these consist mainly

FIG. 1. SKETCH MAP OF NORTHERN PART OF SAN FRANCISCO PENINSULA, showing position of the three faults to which the discussion in this paper is confined.

of half consolidated sands, clays and hard conglomerates, ringing under the hammer. To have removed such a volume of rock would appear to have required most of Quaternary time, especially as the underlying hard pre-Tertiary sandstones, serpentines and cherts were also deeply eroded. During this movement there were volcanic outpourings of some extent. There also appear to have been interruptions to the movement which do not affect the main problem now, and will be passed by. The final result probably left the whole region about San Francisco dry land, except for the water courses. Sand dunes and wash deposits abounded then as to-day. The Monterey cypress and Douglass spruce grew abundantly near San Francisco, some of the latter reaching a diameter of four feet, or more. The mammoth or mastodon roamed the peninsula at that time.

FIG. 2. SECTION OF SEVEN-MILE BEACH AND BEYOND; from mouth of Lake Merced, showing position and exposure of Merced series of rocks. This remnant of this series lies between the San Bruno fault plane at the north and the San Andreas fault at the south. Its entire absence from the San Bruno Mountains to the north and Mount Montana to the south is part of the basis for the theory that since its deposition there has been uplift along the two faults which lifted the terrritory outside of these faults nearly or quite a mile and one half above sea-level, and that erosion, not only planed down the folded rocks of this block, but entirely removed the Merced rocks either side of this block.

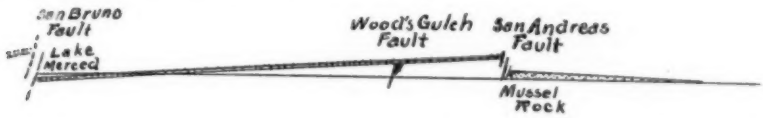


FIG. 3. FIGURE SHOWING POSITION OF RECENT MARINE DEPOSITS ABOVE SEVEN-MILE BEACH and the relative movement along the two fault planes.

Since then two events are clearly shown in the records; these are subsidence and differential uplifts. The subsidence carried most, if not all, of the San Francisco peninsula below its present elevation, flooding the valleys and leaving the hills of the city largely an archipelago. Marine deposits were laid down on top of the clearly recognizable sand dunes and wash deposits, containing in many places the trees mentioned above. Following that came local uplift, raising these marine deposits to elevations of over 700 feet above sea-level just

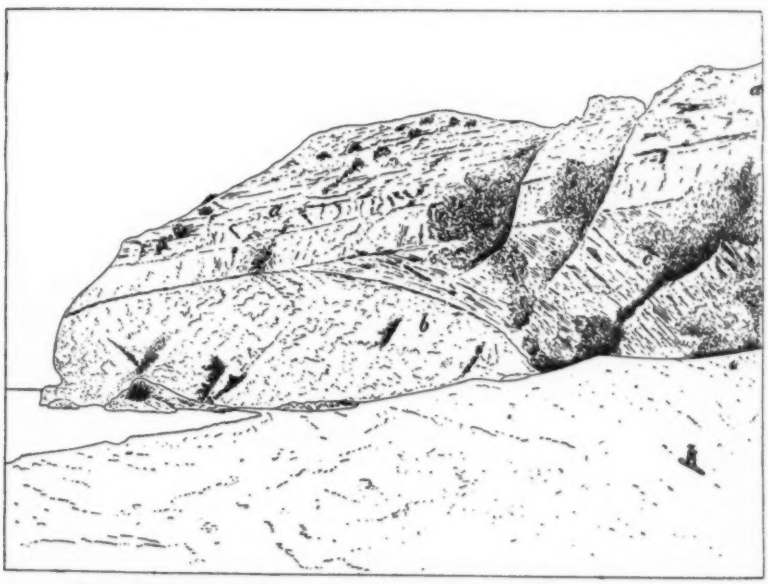


FIG. 4. MUSSEL ROCK FROM THE SOUTH, showing marine Pleistocene (*a*) overlying sand dunes (*c*) and igneous rocks (*b*).

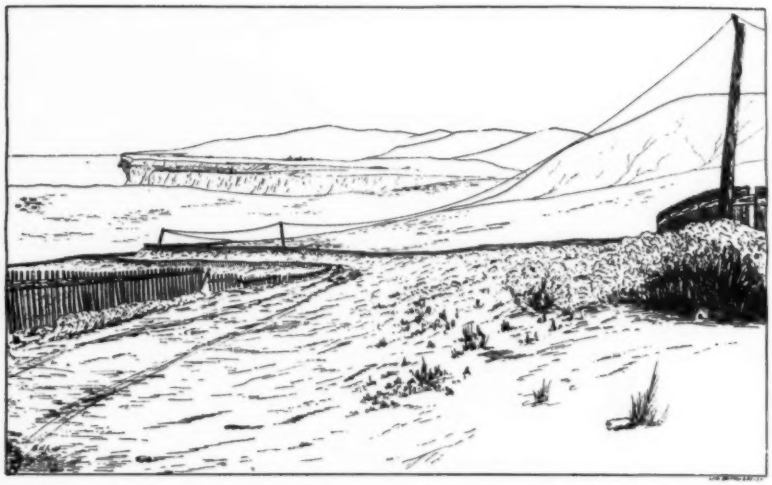


FIG. 5. RAISED BEACH NEAR LOBETUS, Quaternary overlying Merced Strata.

about San Francisco, and double that farther down the coast. These last movements were differential, and it is quite possible that in some cases the two took place together. In the same way, it is quite possible that while in parts of the area the evidence suggests elevation continuing at present, elsewhere subsidence is in progress, though not so evident. The point of special interest in this connection is the fact that this differential movement about San Francisco is clearly a movement of the fault blocks and reveals slipping along these planes of faulting of hundreds of feet in times so recent as to suggest that much of it may have taken place since the human occupation.

Considering first the evidence of movement, a good example is furnished by the San Andreas fault, where it reaches the ocean at Mussel Rock. At the foot of the parallel San Bruno fault a few miles to the northeast the recent marine deposits are about at sea-level. Coming south along the sea-cliff or southwest, these deposits are clearly seen rising, making distinct benches in the little stream valleys where they overlie the wind and wash deposits of the preceding stage, these wash deposits in places being full of half exposed spruce logs, which the neighboring inhabitants use for firewood. Before the San Andreas fault is reached, these deposits have risen to over 700 feet above sea-level, lying on the truncated upturned edges of the Merced strata. As soon as the trace of the San Andreas fault has been crossed, the top of these sediments is found at only 220 feet above sea-level, whence it descends until within a short distance it reaches the level of the beach. Here is therefore clear evidence of movement along the fault plane of several hundred feet since this last submergence. The question of most interest then becomes: How recent was this last uplift?

Farther south on the ocean side of the San Francisco peninsula the coast is fringed with a raised beach, such as occur so abundantly along much of the California coast. The top of this beach is 75 to 100 feet above sea-level. At Purisima, the creek of that name runs out across this raised beach through a slightly cut channel to the very edge of the plane where it drops as a water-fall directly into the surf. As the rocks through which it would have to cut to reach sea-level are the only partly consolidated Merced series, there is striking evidence of the recency of the raising of the beach. Again just south of San Francisco are many places in which the recently raised deposits and in slighter degree the underlying Merced rocks have been trenched to depths of as much as 75 feet since the production of the Coast and Geodetic Survey map of this region in 1869. The fact that so large a part of these recent deposits still remains in view of this rapid erosion impresses one in the field most profoundly.

There is another line of evidence to which the writer refers with some hesitation. Indian shell mounds abound along the California coast. In many cases these now occur spread out in thin sheets, apparently forming the surface layer of the raised beaches over such large areas that in his first study of them he was deceived and considered them in many cases as marine deposits. As he remembers them now, he can not help thinking that in many cases they have been reworked by water before the final uplift. In one case the writer found an Indian skeleton, evidently formally buried, half exposed in the side of a stream channel so narrow as to force one to the conclusion that the channel has been entirely cut since the burial of the body. This is only a fraction of the evidence that in the field leads one to consider this last uplift as a thing of yesterday, and in all probability of to-day also, or, in other words, that these differential uplifts are still in progress.

A final question of maximum interest is: Is there physiographic or

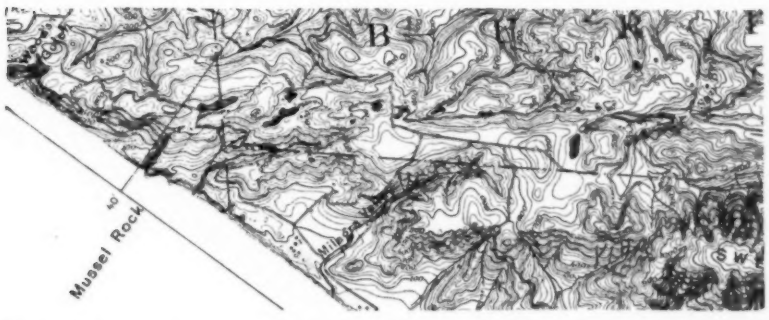


FIG. 6. A PORTION OF THE U. S. GEOLOGICAL SURVEY MAP FROM MUSSEL ROCK southeastward nearly to San Andreas Lake, showing topographic environment of a chain of ponds and undrained basins believed to be due to recent earthquake movements.

other evidence that there has been sudden slipping along these fault lines in very recent years, comparable in importance with movements of two months ago, especially as expressed in fault scarps? According to the preliminary report of the earthquake committee, the rupture of April 18 shows a horizontal displacement averaging 10 feet, and a vertical displacement not to exceed four feet. How long such a surface disturbance can be subsequently recognized is a question. The San Andreas fault belt is well situated for the noting of any such displacement for several miles southeast of Mussel rock, in many cases the actual fault planes emerging in sublevel pasture land at the surface. Neither the writer's notes nor his memory now yield any evidence of such a scarp. On the other hand, the fact that where such evidence might be seen has long been subject to the tramping of cattle renders its absence of less value. In this connection he does not give any value to a small scarp noted just back of Mussel Rock. At the time, it was considered to be a land slip. A photograph taken of it suggests the possibility of its having a deeper meaning.

But if such scarps are lacking, there is abundant evidence of another kind bearing on this subject. I have spoken of the San Andreas fault belt. Such it appears to be rather than a single clearly-defined break. Along this belt between San Andreas lake and where the belt meets the ocean at Mussel Rock is a string of drainless depressions occupied with water part or all of the year. In one or two cases these can be clearly seen to lie directly in one of the lines of faulting. That they are the result of fault movements seems highly probable. When were they made? That they were made within the last few centuries can not be asserted, yet the fact that so many of these shallow basins still exist, neither filled nor drained, notwithstanding that in many cases it is but a stone's throw to the head of a drain with a high gradient, suggests such a possibility. The possible cause of these basins is suggested in what appears to have formerly been one, now trenched from two directions at the head of Wood's Gulch, a small ravine cutting the cliffs of Seven Mile beach, a mile north of Mussel Rock. The ravine follows a fault with downthrow of 800 feet. At the head a cirque-like cut exposed an overhanging fault scarp of 100 feet or more. Against this face there appears to have gradually filled in wash from the adjacent hills, wind-blown sands and detached fragments from the fault face, until the whole thing was buried and later covered with the marine deposits of the last submergence. Judged from what is left of this filling, it must at one time have strongly resembled the undrained basins just described. The evidence suggests that this fault scarp was produced by a single movement. An elephas tusk found about 75 feet from the top of the filled in deposit agrees with the other evidence in placing the time of this movement back to the land period preceding the recent submergence.

Summing up, the evidence seems to warrant the following statements:

1. Since the beginning of Quaternary time there have been differential movements of uplift along fault planes on the San Francisco peninsula amounting in several cases to nearly or quite a mile and one half.

2. That these movements have been followed by subsidence and subsequent uplifts, involving sliding of several hundred feet along the older fault planes.

3. That these last movements are geologically of extremely recent date, that possibly a considerable part of these movements have come since the occupation by the Indians, and probably have continued to the present.

4. That some of the movements along the fault planes, geologically, in fairly recent times, seem to have produced more striking physiographic results than any produced the past spring.

5. That while the recent movement may have relieved the stress which the rocks were under to such an extent that it will be many years, or possibly centuries, before another such a disturbance will take place, on the other hand, a comparison of the few feet of motion in April with the hundreds of feet of movement that have taken place in very recent time suggests that fault adjustments of equal or greater violence are liable to occur at any time in the future. And since similar conditions are known to occur all over the Pacific Coast region, no place in that whole district can claim immunity.

OUR GREATEST EARTHQUAKES[1]

By MYRON LESLIE FULLER
UNITED STATES GEOLOGICAL SURVEY

PROBABLY few people are aware that the greatest earthquake our country has experienced since its settlement was not the destructive shock at Charleston in 1886, or even the recent terrifying manifestation at San Francisco, but was, on the contrary, the now almost forgotten earthquake of New Madrid, the first tremors of which took place on the sixteenth of December, 1811. Strange is that trait of human nature by which even the most appalling of nature's manifestations slip rapidly from the memory, so that only a hundred years later little but tradition remains of the earthquake which changed the configuration of extensive areas of the Mississippi Valley, raising some portions, depressing others, shifting the course of streams, draining old swamps at one point and forming new lakes at others. All this and more, however, took place during the successive vibrations which shook the New Madrid region almost continuously for a period of many months in 1811 and 1812.

The New Madrid Earthquake

The night of December 15, 1811, fell quiet and peaceful, and the settlers retired little dreaming of the impending catastrophe. At two o'clock in the morning, however, they suddenly awoke to find the houses over their heads groaning and cracking, chimneys falling, furniture thrown about, and the earth rocking and trembling. Groping their way to the open fields they huddled together until morning, the shock which succeeded shock at short intervals in the darkness keeping them from returning to their tottering houses. At New Madrid, on the Mississippi, the French population were dancing away the night when the shock came and instantly terminated the revelings, joy being replaced by terror as they rushed from the buildings to the open, where catholics and protestants alike knelt in supplication during the remaining hours of the night.

Daylight brought little relief. At seven a rumbling like distant thunder was heard and in an instant the earth was convulsed so that no one could stand. Looking at the ground the terrified people saw it rise and fall, as earth waves, like those upon the sea, rushed past, waving the trees until their branches interlocked and causing yawning

[1] Published by permission of the director of the United States Geological Survey.

cracks to open where the surface was bent and the swells burst. Giants of the forest were split for forty feet up the stump, half standing on one side of the fissure and the remainder on the other. In one instance a crack opened in a cellar, swallowing a large number of castings just received from Pittsburg and temporarily stored away there.

Some of the earthquake rents were of great size, having widths of thirty feet or more, while some are reported as many as five miles in length. Others were circular in form, making basin-like depressions up to several hundred feet in diameter. Into some of these cracks rushed the waters from swamps and bayous, while elsewhere small streams or even rivers left their old beds and made new channels through the cracks. In one instance, a settler living on a neck of land lying within a great bend or ox-bow started at daybreak the morning after the quake to go to his well which the night before had been in his yard. But no well was there! Instead the river was at his door. Glancing across the water, however, the well could be seen on the further side. During the night a crack had been formed between the house and the well and had been taken possession of by the waters, leaving both unharmed though on opposite sides of the stream.

Accompanying the cracking in many instances there seemed, according to one observer, "a blowing out of the earth, bringing up coal, wood, sand, etc., accompanied with a roaring and whistling produced by the impetuosity of the air escaping from the confinement . . . trees being blown up, cracked and split, and falling by thousands at a time. The surface settled and a black liquid rose to the belly of the horses." The atmosphere was saturated with 'sulphurous vapor,' due to the gases escaping from the decaying vegetation and coaly matter (lignite) deep below the surface in the deposits of the prehistoric Mississippi. These gases tainted the air for miles and so affected the streams and rivers that the waters, even to a distance of one hundred and fifty miles below, could not be used for several days. The intense darkness caused by these vapors in the night, and the murky purplish tinge imparted to the atmosphere by day, produced a vivid and never to be forgotten impression on every one who passed through the experience.

It was along the Mississippi that the destruction reached a maximum. A traveler on a flatboat, tied up to the bank about forty miles below New Madrid, speaking of the first shock, says that the men, wakened by the quake, sprang to the deck thinking the Indians had made an attack. After daylight, as they were preparing to depart, "a loud roaring was heard, sounding like steam escaping from a boiler. This was accompanied by a violent agitation of the shores and tremendous boiling up of the waters in huge swells which tossed the boats so violently that the men with difficulty could keep upon their feet. The sandbars and points of islands gave way, swallowed up in

the tumultuous bosom of the river, carrying down with them the cottonwood trees cracking and crashing, tossing their arms to and fro, as if sensible of their danger, while they disappeared beneath the flood. From the check given to the current by the heaving bottom, the river rose in a few minutes five or six feet and again rushed forward with redoubled impetuosity, hurrying along the boats, now let loose by the horror-stricken boatmen, as in less danger on the water than on the land."

Whole islands disappeared. Captain Sarpy of St. Louis, with his family and considerable money aboard, tied up at an island on the evening of the fifteenth of December, 1811. In looking around they found that a party of river pirates occupied part of the island and were expecting Sarpy with the intention of robbing him. As soon as the latter found that out he quietly dropped lower down the river. In the night the earthquake came, and next morning when the accompanying haziness disappeared, the island could no longer be seen; it had been utterly destroyed as well as its pirate inhabitants.

Few scientists were in the region during the period of shocks, but we are fortunate in having handed down to us a realistic picture from the pen of the great naturalist Audubon.

Traveling through the Barrens of Kentucky (of which I shall give you an account elsewhere) in the month of November, I was jogging on one afternoon, when I remarked a sudden and strange darkness rising from the western horizon. Accustomed to our heavy storms of thunder and rain, I took no notice of it, as I thought the speed of my horse might enable me to get under shelter of the roof of an acquaintance, who lived not far distant, before it should come up. I had proceeded about a mile, when I heard what I imagined to be the distant rumbling of a violent tornado, on which I spurred my steed, with a wish to gallop as fast as possible to a place of shelter; but it would not do, the animal knew better than I what was forthcoming, and instead of going faster, so nearly stopped that I remarked he placed one foot after another on the ground, with as much precaution as if walking on a smooth sheet of ice. I thought he had suddenly foundered, and, speaking to him, was on the point of dismounting and leading him, when he all of a sudden fell a-groaning piteously, hung his head, spread out his four legs as if to save himself from falling, and stood stock still, continuing to groan. I thought my horse was about to die, and would have sprung from his back had a minute more elapsed, but at that instant all the shrubs and trees began to move from their very roots, the ground rose and fell in successive furrows, like the ruffled waters of a lake, and I became bewildered in my ideas, as I too plainly discovered that all this awful commotion in nature was the result of an earthquake.

The vibrations did not cease for over a year from December sixteenth, the date memorable for the first shock. During the succeeding three months 1,874 shocks were recorded, of which eight were violently destructive, ten very severe and thirty-five generally alarming. In fact, this earthquake is famous all over the world as one of the few instances of almost incessant shaking for a period of many months in a region remote from the seat of any volcanic action.

Some, like the first, were accompanied by disruptions of the surface and by changes in elevation of the ground. The country which before the shocks was level, with occasional small prairies, was sadly changed. In places old bayou-lakes were drained so that corn could be planted in their bottoms, while elsewhere lakes of considerable size were created. The surface for hundreds of acres was covered by the sand thrown up with the water from the fissures. Even to this day this can be recognized in the forest, where it occurs as barren spots upon which little will grow.

A few more years and a century will have passed since the shocks so vividly described took place. From a wilderness with a few scattered settlements, the region has become, in the northern part at least, a populous farming region with numerous prosperous towns. The great city of Memphis has appeared near the limits of the earthquake region at the south, while St. Louis with its hundreds of thousands of people is but a little distance outside the area to the north.

Notwithstanding the development of the region and modification of the surface by nearly a hundred years of cultivation, the watchful eye can still detect evidences of the powerful forces which so strongly affected the area in 1811. Throughout all the country from New Madrid in Missouri southward to beyond the Arkansas line, and from the Mississippi river westward to the highlands of Crowleys Ridge, there is hardly an open field which does not show one or more low swells of light sand standing out in marked contrast with the dark soil constituting the ordinary surface. These are the well-known 'sand blows' produced by the actual eruptions of sand and water from considerable depths through cracks in the clayey surface deposits.

Some of the cracks were of considerable length, giving rise to the long narrow 'sand blows,' while others were very short, almost all the water and sand coming from a single point. In such instances little cones or craterlets, as they are called, consisting of low mounds of sand with depressions in the center were often formed.

Even more conspicuous, though less numerous, are the great cracks formed in the earth at the time of the quake. Few people have seen these in their full development, as they are hidden in tangles of vines in the as yet almost untouched hardwood forests on the bottoms of northeastern Arkansas. Turning northward from the lumber town of Parkin about thirty miles due west of Memphis and following the old 'De Soto trail,' in a few hours one reaches the southern portion of the earthquake area and is in the midst of earthquake features of surprising magnitude. The region is low and is frequently submerged for weeks in the spring by backwater from the sluggish rivers, while in summer the cane brakes in the more open spots and the thickets of poison ivy and other vines in the forests present additional obstacles to the explorer. Wild turkeys, deer, wild cats and even wolves are still

1. ONE SIDE OF EARTHQUAKE CRACK IN NEW MADRID REGION, showing scarp 4 feet in height. (Photo by Fuller.)

2. LANDSLIDE SCARPS NEAR REELFOOT LAKE, TENN., produced by New Madrid earthquake. (Photo by Fuller.)

found. There are no roads, and for many miles not even a solitary settler is to be seen, but with a good horse and a guide familiar with the cracks, blows and 'sand slews,' the region can be penetrated and the earthquake features examined. It is in the depths of these forests along the St. Francis river that the cracks reach their greatest development. How wide they may have been when first formed and how deep, no one can tell. The originally steep banks have crumbled and the fissures partly filled until at the present time they resemble a deep ditch more than a crack. Yet some of these ditch-like depressions are still thirty feet or more across and so deep that a man on horseback can not see over the top, even when he has succeeded in scrambling or sliding down the steep sides. From cracks of this size there are all gradations down to little ones of only a half a foot in depth, but all are still distinctly recognizable. Most of them are within a quarter or half a mile from some river and have a general north-south direction, as if the surface of the land shifted bodily towards the waterways, leaving great rents in the ground where the materials parted. One of the smaller of the cracks is shown by one of the illustrations of the present article (Fig. 1).

3. TREES TILTED BY NEW MADRID EARTHQUAKE. (Photo by Fuller.)

Fissures of another, but equally conspicuous type are the land-slide cracks formed where steep slopes, such as those along the east side of Reelfoot Lake in western Tennessee, occurred within the earthquake area. Here the bluffs, which are several hundred feet in height, were literally shaken to pieces by the shocks, the trees uprooted, overturned, or prostrated, and great masses of earth precipitated down the steep hillsides. Figure 2 shows some of the scarps thus formed, while another shows trees overturned at the same time (Fig. 3). Sometimes the original trunks are decayed and gone, all perhaps but a projecting stump, but shoots from the original have often taken their place as giants of the forest.

The features for which the New Madrid earthquake is most renowned, however, are the swamps and lakes which resulted from the warping of the surface. The former may be seen at many places in southern Missouri and northern Arkansas. In the view of such a

swamp here given, the water growth in the foreground and the dead trunks of the old trees are in contrast to the dense growth of new timber which is gradually reclaiming the swamp (Fig. 4).

Reelfoot Lake, the most noted single feature resulting from the earthquake, is a shallow body of water between the Mississippi river and the Chickasaw Bluffs in western Tennessee. It has a length of about twenty-five miles, a width of about five miles, and a depth of twenty-five feet or more. Previous to the earthquake, it is said, no lake existed, the lands being of the ordinary type of fertile bottoms

4. VIEW IN SUNK LANDS FORMED BY NEW MADRID EARTHQUAKE IN SOUTHEASTERN MISSOURI.. (Photo by Fuller.)

characteristic of the Mississippi, and had early been granted by the Spanish to certain favored individuals. Through the land ran Reelfoot Creek, a little stream rising in the highlands on the east.

After the earthquake all was changed. A warping of the surface occurred across the course of the little Reelfoot Creek, the channel in the lower portion being lifted above its old level so water no longer flowed through it, while the upper part sank and was soon covered by the waters that collected behind the barrier. The old channel can still be traced by soundings across the lake and the landmarks bounding the early grants made out beneath the waters, while to the south the nearly dry bed of the unlifted creek may be traced to the Mississippi (Fig. 5).

Comparison with Later Earthquakes

In earthquake studies one of the most fascinating lines of research is the investigation of the relative intensities of the different shocks. Of the various evidences, that afforded by the resulting disturbances of the surface conditions is most reliable. Accounts of those who have felt the shocks are unreliable in determining intensities, since the feelings experienced at such a time are largely dependent upon nervous temperament, and upon previous experiences with earthquakes. One feeling a shock for the first time is often seriously disturbed by tremblings to which a resident of an earthquake country would not pay the slightest attention.

5. Old and Young Growth of Cypress in Reelfoot Lake, Tenn. The large stumps without enlarged butts are the old trees killed by the New Madrid earthquake. The living trees with enlarged butts are mainly subsequent growth.

A comparison of the effects produced upon artificial structures and upon the earth's surface by our three great earthquakes, New Madrid, Charleston and San Francisco, seems to show that of the various types of phenomena associated with earthquakes, nearly all were more strongly developed at New Madrid than at either of the other localities.

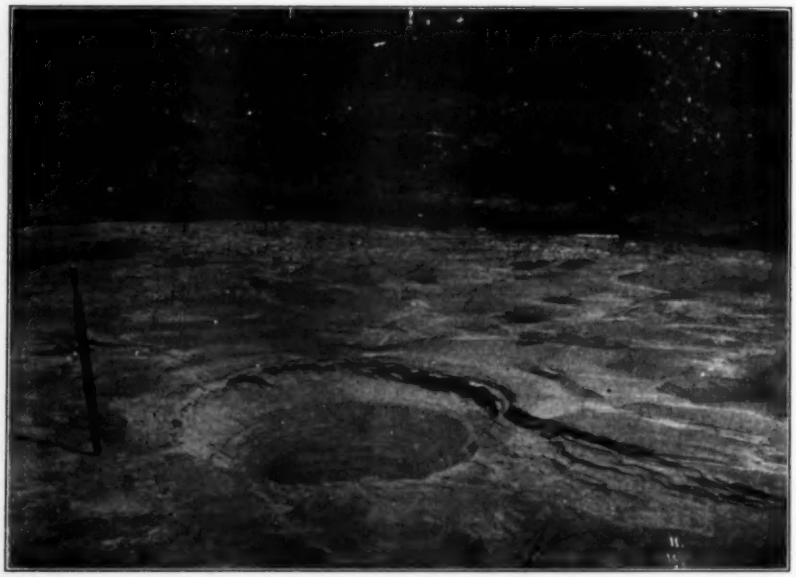
The length of the period of marked disturbance at San Francisco was only a few minutes during the eighteenth of April of this year. The Charleston earthquake occurred, after a preliminary tremor a day or two before, but not felt in the city on August 31, 1886, the severe shocks being confined to a few hours, although not entirely ceasing for three months. In New Madrid, on the other hand, the vibrations,

which began on December 16, 1811, continued almost unceasingly for several months, while for more than a year they recurred at frequent intervals. Even at the present time there is probably not a year goes by without a distinctly recognizable shock.

In San Francisco few of the better class of buildings were destroyed, and in Charleston, although the damage was great, few buildings collapsed completely, and the cabins were seldom more than shaken from their foundations. In the New Madrid region there were no high buildings, one story log or frame houses being the rule, but notwithstanding this many are said to have been shaken to pieces by the relatively intense shock.

Again, no progressive wavelike undulation of the surface of any magnitude was recognized at the time of the shock at San Francisco, but at both Charleston and New Madrid the surface rose and fell in waves several feet in height. In Charleston the forests were but little affected, but at New Madrid the trees were often thrown together upon the ground in confused heaps or snapped sharply off near the ground as by an axe.

The streams in the vicinity were little affected by the San Francisco shock, and even at Charleston few if any permanent changes resulted from the earthquake, but in the New Madrid region the effect of the disturbance was very marked. The courses of some of the streams were changed—the water following new cracks instead of the old channels. Others were deflected by warpings of the surface, and still others by sharp uplifts or faults, giving rise to swamps or bodies of open water.



6. Earthquake Craterlet near Charleston, S. C., as it appeared immediately after the shock.

Cracks were formed by the earthquake in each locality. In San Francisco except along the immediate line of faulting they were few in number, small in size, and limited to small tracts of especially soft ground or to the steeper hillsides. In Charleston they occurred over an area several miles in diameter, but were usually under an inch across, except near the rivers. At New Madrid, on the other hand, they extended over an area many times as great, extending from southern Missouri nearly to Memphis, a distance of over one hundred miles, and from one side of the Mississippi Valley to the other, and were often many feet in width. No sand is reported to have been thrown from the cracks at San Francisco except in rare cases, but at Charleston numerous craterlets such as shown in one of the accompanying illustrations were formed, from which large amounts of sand and water flowed out quietly upon the surface (Fig. 6). At New Madrid the sand and water not only came out more frequently and covered a larger area, but were ejected with violence, sometimes reaching, according to observers, to the very tree tops.

Little change of level occurred at either San Francisco or Charleston, but in the New Madrid region great areas sank and were covered by water, one of them now covered by Reelfoot Lake being over twenty-five miles long and more than five miles wide.

Cause of the Shocks

The shocks in each case have had their origin in the breaking and slipping of hard rocks underneath. All rocks of the earth's crust are subjected to stresses of different kinds, such as may be produced by the weight of overlying material, by the shrinking of the earth's interior, or by other causes, and the time comes when their strength is no longer sufficient to resist them, and a break occurs, usually accompanied by a crushing of the rock along the fracture or by a slipping of one part of the rock over the other. It is this slipping or crushing which gives rise to the vibrations known as earthquakes.

In the San Francisco region this slipping is constantly going on and minor shocks have been of frequent occurrence. It was only a slightly larger slip than usual which produced the recent disastrous shake. In Charleston the slipping was mainly at one time, no preliminary shocks of importance were felt and few occurred afterwards, except during a short period immediately following the earthquake, but in the New Madrid country the quaking has continued for several hundred years at least. Both the Charleston and New Madrid earthquakes occurred in regions where the earth's crust is being overloaded—in the one instance by the sediments brought down by streams from the Appalachian Mountains and in the other by the floods of the Mississippi—and the fracturing is believed to have resulted from the readjustment of the harder rocks to the increasing load.

A Look into the Future

As to what the future holds in store for the three regions we can only judge by the past. The Charleston earthquake, as far as shocks of any intensity in recent times are concerned, is unique in the Atlantic Coastal region. The equilibrium has probably been regained since the slip of 1886, and it may be ages before another occurs. San Francisco, on the other hand, is in an earthquake region, shocks are of common occurrence, and another of an intensity equal to or greater than the recent disturbance may occur at any time, although, on the other hand, the temporary adjustment brought about by the recent slip tends to decrease the danger of an immediate severe shock.

In the New Madrid area, however, the earthquake of 1811–12 was only one of a series. Cracks may be found with trees fully 200 years old growing in their bottoms, indicating early shakes of equal if not greater intensity than the last. Nor has the movement yet ceased. Every year there are one or more shocks, sufficient to shake objects from shelves, and to seriously affect wells and springs. Only last summer the newspapers were full of accounts of such a shock in southeastern Missouri and adjoining regions—the very area of the New Madrid earthquake. If there have been two or more strong shocks with an intensity far greater than the Charleston quake, and if the readjustment is not completed as is positively indicated by the recent shocks, then there is every reason to believe that disturbances of equal severity may occur in the future. Such quakes, it goes without saying, would be disastrous to such towns as Hickman in Kentucky, Caruthersville, New Madrid, Campbell and others in Missouri, all of which are in the area of disturbance. The larger cities of Cairo and Memphis, although outside the main area, would also probably suffer severely, as they are built on soft deposits overlooking the Mississippi in situations favoring easy slipping towards the streams. Such spots were often severely fissured by the early quake, large masses slipping into the river, and what has occurred once may occur again. St. Louis would also probably be severely shaken, but its buildings are less liable to destruction from a shock originating in the New Madrid area because of the remoteness from the point of disturbance.

SHORTER ARTICLES

THE EPIDEMIC OF TYPHOID FEVER AT PALO ALTO.

In the spring of 1903, the university community at Palo Alto was startled to find that in about two days upwards of one hundred and thirty students and about a hundred other people—most of them living in the town of Palo Alto, but a considerable number also in fraternity houses on the university campus—were attacked by typhoid fever. The Students' Guild, the cooperative hospital association of Stanford University, immediately set to work upon the problem of furnishing hospital service, while the department of hygiene of the university and the board of health of the town of Palo Alto devoted themselves to the investigation of possible causes for the outbreak.

The university town, with a population of about four thousand, was entirely new and its health conditions were ordinarily of the very best, there being no slums, cesspools or foulness of the ordinary sort. Every sanitary precaution had been taken in the lodging of students. The water supply was above suspicion, being drawn from deep-driven wells. The whole difficulty was finally traced to a single small dairy, the milk of which had been the source of the infection.

A full account of all elements concerned in this case has been published in a pamphlet for free distribution, by Professor J. C. L. Fish, of Stanford University, president of the Board of Health of Palo Alto, together with analyses of reported cases by Dr. C. D. Mosher, and a discussion of the source of infection of the milk supply by Dr. William F. Snow. In view of the lesson to be derived from this case and from the nearly parallel outbreak at Cornell University which preceded it, an account of the method of infection may be found interesting and useful.

The report shows that there were no cases of typhoid fever in Palo Alto, so far as known, between 1894 and 1903. On investigation it was found that the one thing in common which connected the different houses in which cases were reported, was the milk supply. On further investigation it was found that the milk man got a portion of his milk from a Portuguese dairy about five miles from the university on a little brook tributary to Los Trancos Creek. Samples of the water used in washing the cans and cooling the milk were examined by bacteriologists and found to contain large quantities of the bacillus *coli communis*, the well-known bacillus of typhoid fever.

The investigation of the sources of infection at the Portuguese dairy reads like the plot of a tragedy. The scene is laid in the month of December, 1902, at Stanford University and Palo Alto and the immediate vicinity. The *dramatis personæ* are taken from homes all over the country. The Serpa house, where the trouble begins, is situated on the banks of the Madera Creek, three miles above Mayfield. A cousin, from San Francisco, comes to visit the Serpas. Soon after his arrival he complains of feeling ill, and Mrs. Serpa nurses him; she does not consider him sick enough to demand the services of a physician. One week later the relative is better, but Mrs. Serpa is quite sick herself and Serpa calls in a doctor, who pronounces the case one of typhoid fever. A few days more and two of the Serpa children are taken ill with symptoms identical with those of the mother and the cousin. Serpa now becomes thoroughly fright-

ened and abandons what little cooperation in medical and sanitary precautions up to this time he has given to the physician. Confusion reigns in the Serpa house, and many friends come from the surrounding ranches to nurse the sick and to sympathize with distressed husband and father.

The San Francisco cousin, Serpa's wife and the two sick children of Serpa die of typhoid fever. Friends again come to console and remain to be consoled by food and drink. Among the guests are N. and N.'s wife from the N. dairy, P. and the family of P. from the P. dairy, an aunt and her daughter from San Gregorio (a seacoast town forty miles away) and a Portuguese family living on Los Trancos Creek on the road from the P. dairy to Palo Alto.

When the aunt, with her daughter, leaves the Serpa house, she takes with her two of the Serpa children. The first act ends with the general breaking up and dispersion of these solicitous friends to their respective homes.

The second act begins January, 1903. N. and the wife of N. lie sick at the N. dairy with typhoid fever. N. dies.

P. lives on the banks of Los Trancos Creek, a few hundred feet above the intake of the dairy water system; there are no buildings higher up on the drainage area of the system. Nineteen Filipino wood choppers and a hundred lumbermen are employed in the hills surrounding the P. dairy; they visit the dairy ranch. On the banks of the creek, near the pig pen and just above the dairy water supply intake, are primitive out-house facilities for these laborers.

P.'s child is sick with fever. P. complains of a general malaise. At the aunt's house in San Gregorio, the aunt and her daughter and the two Serpa children are ill with typhoid fever. In the Portuguese houses on Los Trancos Creek, on the road from the P. dairy to Palo Alto, are five cases of typhoid fever. At Stanford University and Palo Alto there are two hundred and thirty-six cases of typhoid fever. The black pall of death hangs over the university and Palo Alto. Parents all over the country sit in darkened homes with bowed heads and mourn for the dearly beloved son or daughter, while the health officers work with sleepless activity. "By the process of elimination and by the sequence of events connecting the typhoid fever at the Serpa house with the P. illness, the outhouse on the bank of the P. creek, the rains and the impounded water at the dam, the conclusion is reached that the P. milk was infected through admixture with the creek water used at the milk house of the P. dairy."

Dr. Clelia D. Mosher's contribution to the 'report' contains an exhaustive study of the symptoms, relapses and complications of the reported cases. The analysis is based on the detailed reports of the physicians, supplemented by statements from the families and the individuals affected, together with a careful investigation of the death records. The total number of cases reaches 236; this number includes 24 known cases for which no reports were obtained, occurring among students who had left Palo Alto after the outbreak of the epidemic.

The ages of the patients vary from two months to sixty years. Dr. Mosher shows that the most susceptible age, between fifteen and thirty years, is far above the average and explains the number of children infected by the fact that milk was the source of infection.

EDITH V. MATZKE.

THE PROGRESS OF SCIENCE

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

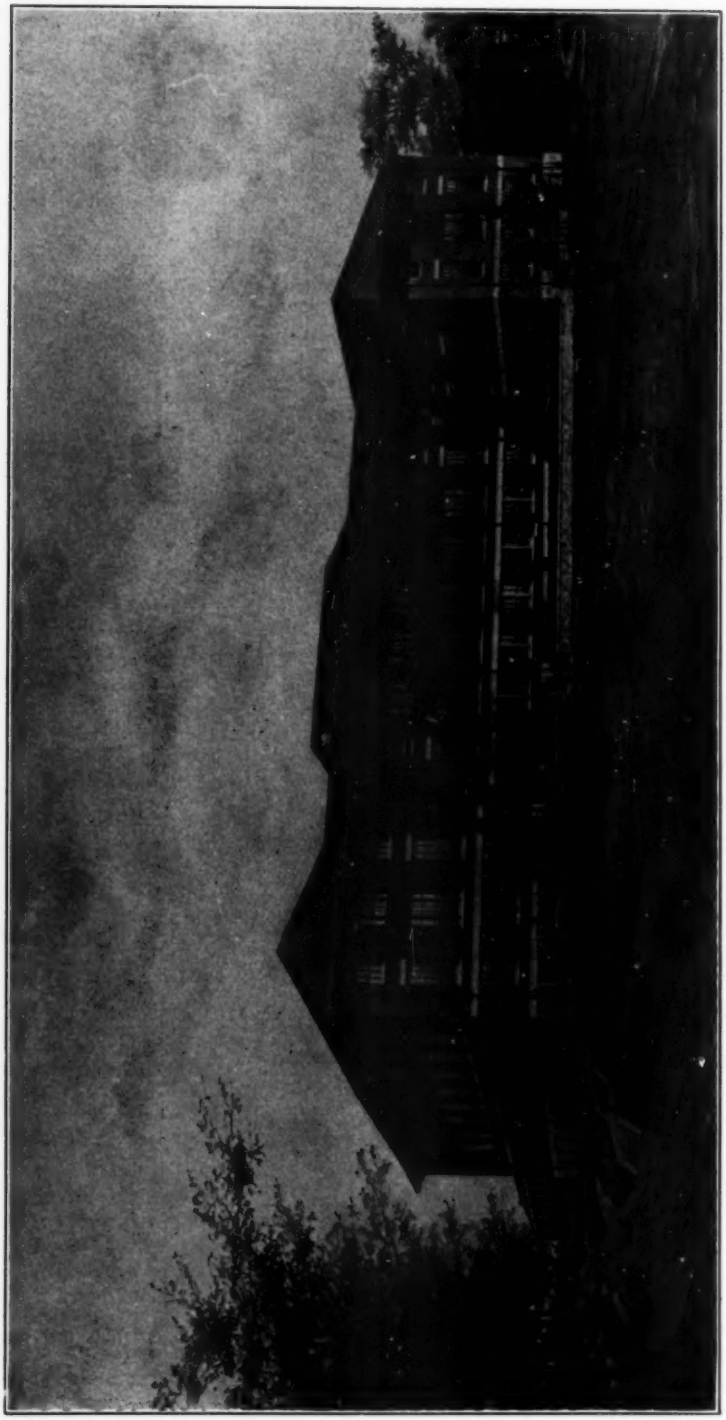
At the New Orleans meeting of the American Association for the Advancement of Science the council voted that in addition to the regular winter meeting, a summer meeting should be held at Ithaca, N. Y., from June 29 to July 3. For such an experiment, and the holding of more than one meeting a year is avowedly an experiment, the place is well chosen. Ithaca is a university town and well adapted by climate and situation for a summer meeting. The campus, where these sessions will be held, is green and well shaded. It is nearly 1,000 feet above sea level and overlooks from a height of 400 feet one of the most famous and beautiful of the lakes of central New York.

In the immediate neighborhood of Ithaca are many places of scenic as well as scientific interest. At Taughannock, about eight miles away, a water fall, 215 feet in height, plunges into an amphitheater the forest-topped walls of which rise vertically more than 300 feet above the bed of the stream. Lucifer Falls at Enfield about the same distance and numerous other cataracts in the glens formed by the tributaries of Cayuga Lake are also of great interest and beauty. The local committee is arranging for various short excursions to these places and also one to the widely known sociological colony—the George Junior Republic. Some of the sections are planning to devote their meetings exclusively to field work and excursions. Papers will be read and discussions held at the places visited during the excursions.

On Thursday evening, June 28, there will be an informal smoker at the Town and Gown Club of Ithaca. On Friday afternoon, June 29, the new Physics Laboratory of Cornell University—Rockefeller Hall—will be opened and several well-known men of science will speak. On Monday evening, July 2, a public address, by Professor J. C. Branner, of Stanford University, on 'The Great California Earthquake,' under the auspices of the society of the Sigma Xi will commemorate the twentieth anniversary of the founding of that organization. Other public lectures will be given by President David Starr Jordan, of Stanford University, on 'The San Francisco Disaster'; by Professor Henry S. Carhart, of the University of Michigan, on 'The South African Meeting of the British Association for the Advancement of Science,' and by Major General George W. Davis, U.S.A., on 'The Great Canals of the World.'

In addition to the usual meetings of sections, a number of special societies will hold sessions in conjunction with the American Association. Among these are the Society for the Promotion of Engineering Education, the American Physical Society, the American Chemical Society, the Society for Chemical Industry and the American Microscopical Society.

As has been said the holding of a summer as well as a winter meeting of the association is an experiment, but it is an experiment which should have the active cooperation of all those who are interested in the advancement and diffusion of science. Until 1902 the association met in the summer, and other scientific societies met in groups during the Christmas holidays. For a large and technical meeting, the winter is the best season, and a large city



ROCKEFELLER HALL; THE NEW PHYSICAL LABORATORY OF CORNELL UNIVERSITY.

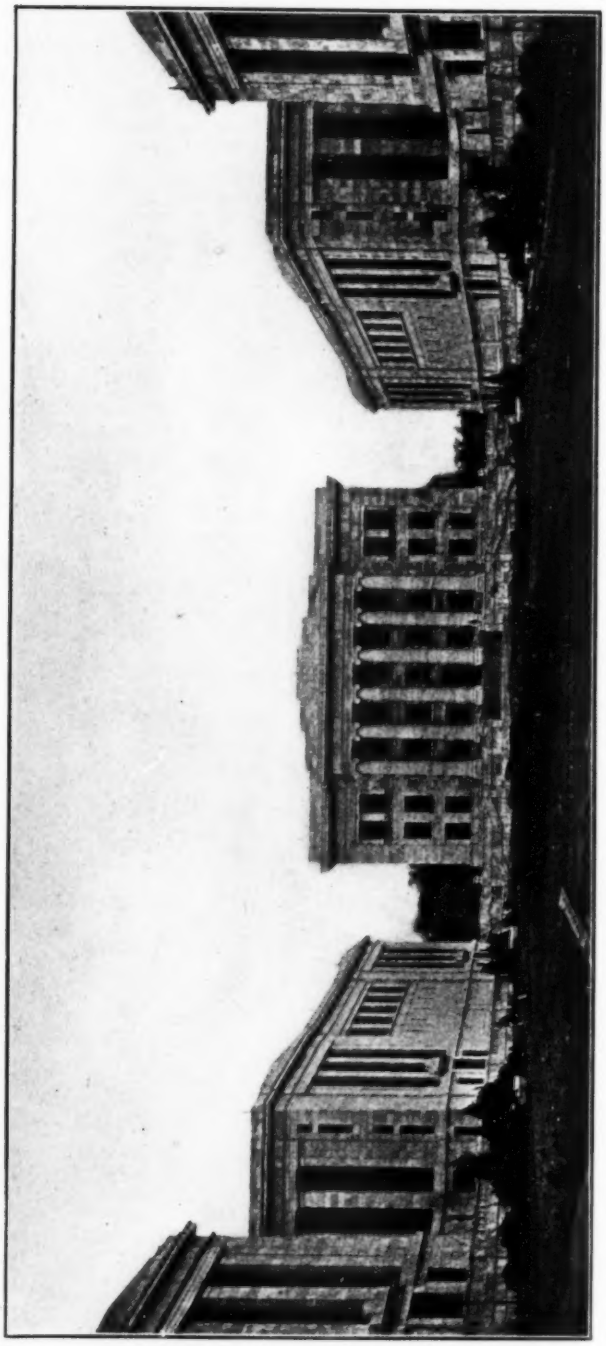
must be chosen. But many members of the association have regretted the abandonment of the summer meetings, which could be held in a university town or summer resort, when out-of-door life and excursions are pleasant, and where old acquaintances and friends may be met and new ones made. The American Association has now more than twice as many members as in 1900, and it should be able to increase its service by holding meetings that will fill the needs of all. It is to be hoped that those who believe that summer meetings are desirable or that the experiment should be tried will go to Ithaca. Whether the meeting is large or small, it will surely be interesting and enjoyable.

THE BOSTON MEETING OF THE AMERICAN MEDICAL ASSOCIATION.

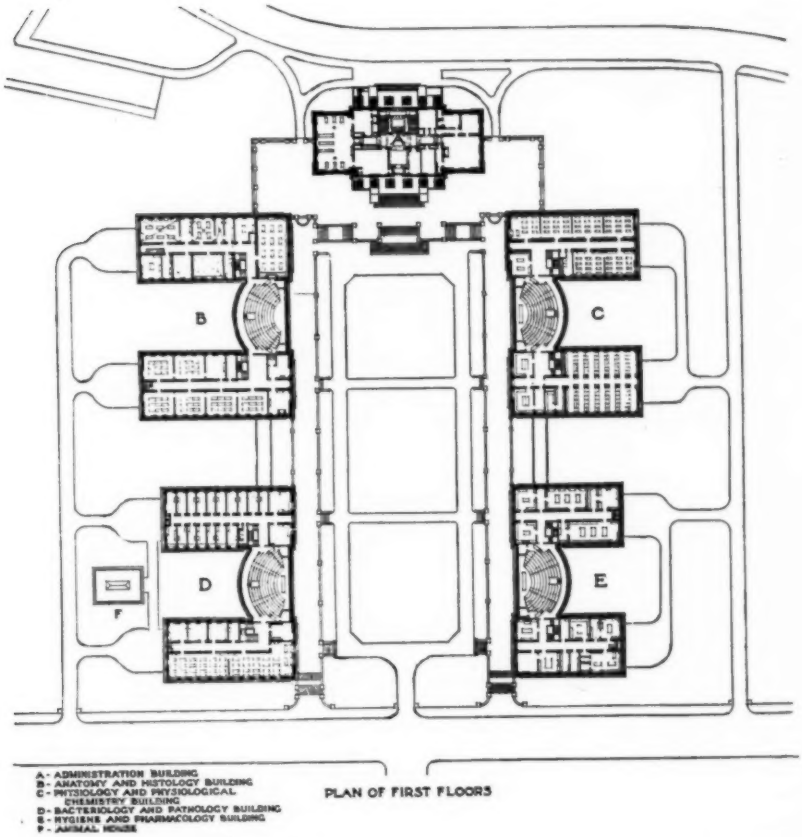
THE fifty-seventh annual meeting of American Medical Association which began at Boston on June 5 was the largest and most notable in its history. There were about five thousand members in attendance; the scientific sessions improve from year to year, and the organization becomes more efficient and influential. Washington, New York and Boston are the three chief scientific centers of this country. Of the one thousand leading scientific men 119 are in Washington, 119 in New York and 85 in Boston-Cambridge. But historic continuity has been longest maintained at Boston, and it seems to lend itself better than any other city to a large scientific gathering. There the American Association for the Advancement of Science, the National Educational Association and now the American Medical Association have held their largest meetings. The governor of the state and the mayor of the city maintain the tradition of being gentlemen, while a welcome from President Eliot gives distinction to any gathering. The conditions in Boston are more nearly those of an English city, and the formal functions, the receptions and the garden parties pass off more smoothly and with less artificiality and aimlessness than in other American cities.

After the greetings of the opening session, Dr. Louis McMurtry, of Louisville, Ky., the retiring president, introduced the president elect, Dr. William J. Mayo, of Rochester, Minn., who made the annual address. It was concerned mainly with the organization of the medical profession and its relations to the public, emphasizing, though perhaps unconsciously, the trades union character of the association. Among the topics reviewed were: the need of union to promote not only the interests of the profession, but also the welfare of the public; the function of the medical profession in enlightening the public in regard to sanitation, the dangers from poisonous nostrums and the need of compulsory vaccination; the improvement of the army and navy medical departments; the supervision of medical schools and reciprocity in medical licenses; the relations of physicians to the insurance companies, contract practise, and hospital abuse by patients who are able to pay; the financial position of the physician and the evil of accepting commissions from specialists; the strained relations between medicine and pharmacy. In conclusion Dr. Mayo said: "The vital need of the medical profession is a harmonious organization—an organization that will encourage right thinking and good usage among ourselves, help to secure needed medical reforms, compel redress of grievances and promote and encourage the highest interests of its individual members: and in this lies the future usefulness of the profession as a whole."

The organization of the association has resulted in the 'house of delegates,' representing the medical profession through the states. The county medical societies unite in a state society and the state societies in the national association. The subjects dis-



THE NEW BUILDINGS OF THE HARVARD MEDICAL SCHOOL.



cussed in the sessions of the house of delegates were largely those referred to in the address of the president. The strength of the association is indicated by the fact that it has nearly 25,000 members and an annual income of about $275,000. Its *Journal* is an important factor in organization and in the advancement of medical science.

For the presentation and discussion of scientific papers the association is divided into numerous sections. The programs at Boston were better than ever before, but the papers were very diverse in method and uneven in value. The scientific exhibits were unusually good, and were seen to much advantage in the new Harvard medical buildings, themselves an exhibit of unsurpassed importance.

THE NEW HARVARD MEDICAL SCHOOL

THE new buildings of the Harvard Medical School are beautiful beyond illustration or description. They are a renaissance and reincarnation of the spirit of Greek simplicity, dignity and perfection. It is probable that there are no other academic or public buildings in America having equal distinction and beauty. This, at least, was the impression made on the present writer, in spite of garden parties and unkempt surroundings. This opinion, if conferred by competent judges, deserves special emphasis, because the laboratories and lecture-rooms have not been put into buildings designed to look well, but the buildings were made for their uses in accordance with plans of

members of the Harvard medical faculty. The thanks of all men of science are due to the architects, Messrs. Shepley, Rutan and Coolidge.

Professor Minot proposed the 'unit system' and Professor Porter the arrangement of two wings with a common lecture-room and library. The unit adopted for the laboratories is 23 x 30 feet, accommodating 24 students. Each unit has three windows and can be subdivided into two or three rooms. The smaller rooms for individual research are also divided into mezzonine storeys. The windows extend to the ceilings, giving abundant light, and the architectural effects are in some measure due to the piers of pilasters between the windows. The buildings can be extended by adding new units, and would finally form courts.

The arrangement of the buildings is shown in the illustration and by the ground plan. The administration building contains offices, common-rooms, lecture-rooms and the Warren Museum with an area of 22,000 square feet. The laboratories are for anatomy and histology, physiology and physiological chemistry, pharmacology and hygiene and bacteriology and pathology, each pair having a common amphitheater and library. The arrangements for heating, ventilation, refrigerating, etc., are very complete.

The large cost of these buildings appears to be justified, as the money was given for them and might be charged to the city of Boston and the people of the country as well as to medical education. It is said that the gray marble added only three per cent. to the cost. The buildings do not, however, provide for clinical work, and as there are altogether only 287 students in the school, the rent to be charged to each student is in the neighborhood of $500. The number of students will, however, increase. The need of four similar amphitheaters, each seating 265 students is not clear. They may be built for the future, but the future may show the futility of lecturing to large audiences of medical students. Here the unit system seems to be lacking where it was especially needed. Still less evident is the desirability of four separate libraries which will apparently be both expensive and inconvenient. But the fundamental criticism which must be made is the permanent separation of the medical school from the rest of the university. It appears to the present writer that Harvard has done great harm to itself and to education by segregating both in time and space the work in medical science. It requires the bachelor's degree for entrance to the medical school, whereas if the sciences preliminary to medicine were carried on at the college, the liberal studies would become less aimless and the professional studies more liberal. The separation of liberal studies, professional work and research does injury to each.

MR. ADAMS ON THE AMERICAN COLLEGE.

THE Phi Beta Kappa address given by Mr. Charles Francis Adams at Columbia University has been printed in the daily papers of more than one city, with abundant editorial comment and letters from correspondents. This means that the address was concerned with an interesting problem or, at all events, attacked a problem in an interesting way. Mr. Adams is alleged to have said when engaged in writing a book upon Puritan life, "I never have been so happy as during the last year; I have been destroying people's ideals." At all events he confesses in the present address to 'a decided lack of faith in ideals.' The iconoclasm is entertaining, and it may be profitable, but apart from the characteristically personal form of expression it is not new. Neither is the remedy new though it is claimed as such in Touchstone's words: 'An ill-favored thing, sir, but mine own.'

Mr. Adams became academically famous in 1883 by another Phi Beta Kappa address on 'The College Fetich,'

namely, Greek. He now finds that there are things in colleges that are worse than Greek, namely, the elective system, which he calls crude, ill-considered, thoroughly unscientific and extremely mischievous.' The address may be fairly represented by the concluding paragraph, which reads:

"For him who graduated half a century ago, the game is now either won to a degree or irretrievably lost. But, reviewing his record, he is apt to see with great distinctness the nature of the game, and wherein his play was defective, wherein correct. For myself, thus retrospecting, I am constrained to say that, as a training place for the game in which I was to take a hand, the college of the period—and Harvard stood first among them—viewed as a mental gymnasium, was ill-adapted to existing conditions, unsympathetic, and, as respects organization, already distinctly outgrown. In the matter of intellectual training, it was a period of transition—the system of prescribed studies was yielding to a theory of electives. So far as it had then been developed and applied, the new system proved in my experience a delusion, a pitfall, and a snare. My observation, as I said in the beginning, leads me to apprehend that conditions in these respects have not since changed for the better. The old organization yet lumbers along; the implicit belief in the pursuit of aptitudes on lines of least resistance is in fullest vogue. Could I, on the contrary, have my way, I would now break our traditional academic system into fragments, as something which had long since done its work and is now quite outgrown; and I would somehow get back to the close contact of mind upon mind. I would to a large extent do away with this arms-length lecture-room education for the college period. I would develop an elective system based on scientific principles, and the study of the individual; properly regulated, it should be intelligently applied. I would prescribe one of the classic tongues, Greek or Latin, as a compulsory study to the day of graduation, the one royal road to a knowledge of all that is finest in letters and art. I would force every student to reason closely all through his college days; while no man not trained to observe, and equal to tests in observation, should receive a degree. Beyond this I would let the student elect.

THE CAUSES OF DEATH.

THE Bureau of the Census has issued a special report on statistics of mortality from 1900 to 1904, which gives important information in regard to the prevalence of certain diseases.

Tuberculosis of the lungs and pneumonia were by far the leading causes of death. The average annual mortality from tuberculosis of the lungs, or consumption was 172.6 per 100,000 of population. The rate has shown a marked decline since 1890, when it was 245.4. The mortality from this disease in the registration area in the United States is lower than it is in Ireland, Germany, Norway, Spain and Switzerland, but higher than in England and Wales, Scotland, the Netherlands, Belgium and Italy.

Pneumonia was second among the principal causes of death, the average annual rate being 165.6 per 100,000 of population. In the registration states the mortality from pneumonia was about 50 per cent. higher in the cities than in the rural districts.

Heart disease was third among the leading causes of death, the average annual rate in the registration area for the five years being 120.9 per 100,000 of population.

Among the leading causes of death, diarrhoea and enteritis were fourth, the average annual mortality from this disease for the five years being 113.1 per 100,000. Over 80 per cent. of the deaths from these diseases were deaths of children under 5 years of age, and over 65 per cent. of children under 1 year of age. The average annual death rate from these diseases was about 75

per cent. higher in the cities than in the rural districts.

The average annual death rate from typhoid fever in the registration area was 33.8 per 100,000 of population. Of the ten European countries for which similar statistics are available Italy alone shows a higher. The mortality from typhoid fever was excessively high in Pittsburg, Cleveland, Cincinnati, Columbus, Louisville and Washington. The average annual rate was much below the average in New York City, St. Paul, Milwaukee, and Jersey City.

SCIENTIFIC ITEMS

DR. A. GRAHAM BELL, the inventor of the telephone, has been given the doctorate of laws by the University of Edinburgh.—The United States ambassador to Great Britain, Mr. Whitelaw Reid, has presented the gold medal of the American Geographical Society to Captain R. N. Scott, commander of the National Antarctic Expedition.—Dr. Joseph D. Bryant, of New York City, has been elected president of the American Medical Association.—At the recent International Medical Congress at Lisbon, the Moscow prize was awarded to M. Laveran and the Paris prize to Professor Ehrlich.

THE International Congress of Applied Chemistry at Rome resolved that the seventh congress shall be held in London, with Sir William Ramsay as the president and Sir Henry Roscoe as honorary president.—The sixteenth International Medical Congress will be held at Buda Pesth in 1909, under the presidency of Professor C. Müller. It is likely that the following congress will be held in New York City.

THE Prince of Monaco has offered to give his Museum of Oceanography and Laboratory for the Investigation of the Seas, now at Monaco, to the city of Paris, with an endowment of $1,000,000. The institution is to be under the charge of an international committee.—It is announced that Mr. David Rankin, of St. Louis, has decided to give $2,000,000 to found an industrial and manual training school in St. Louis.—Arrangements have been completed, under a plan outlined by Alfred Mosely, to send, between November and March, five hundred British teachers to the United States and Canada to study the educational systems of the two countries.